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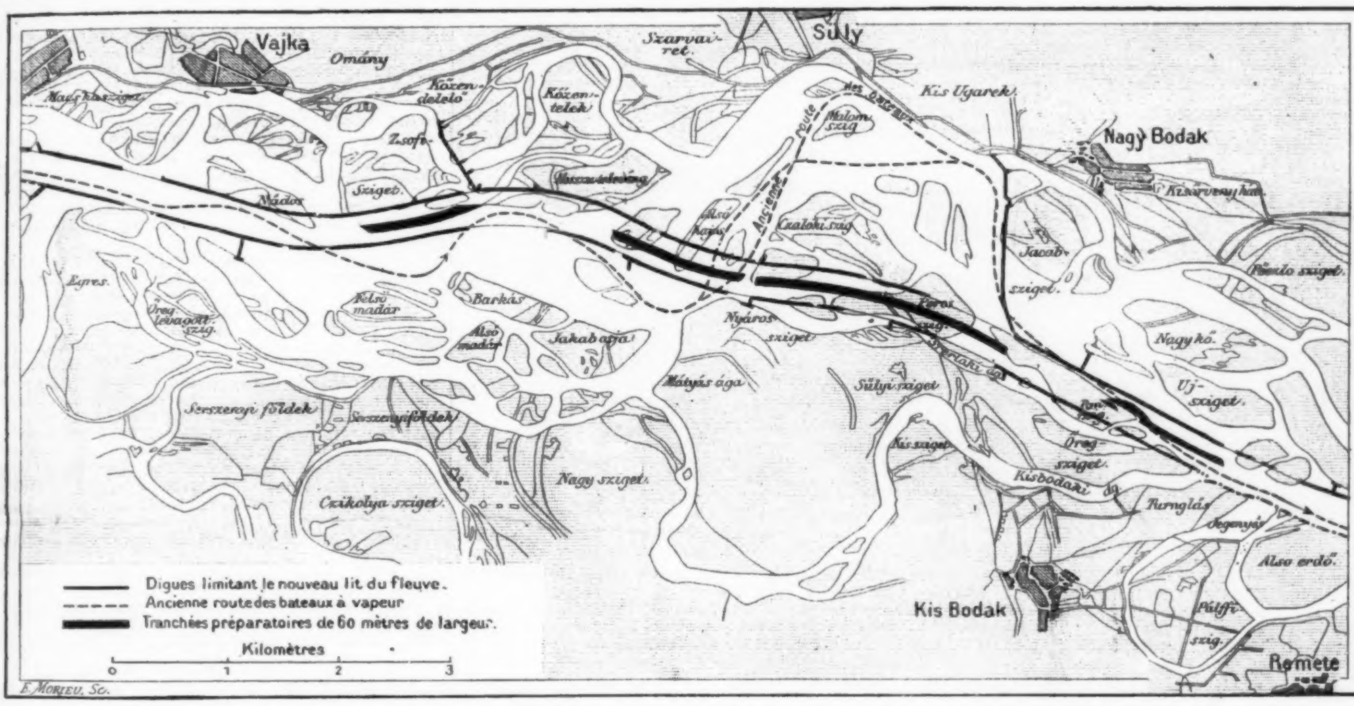
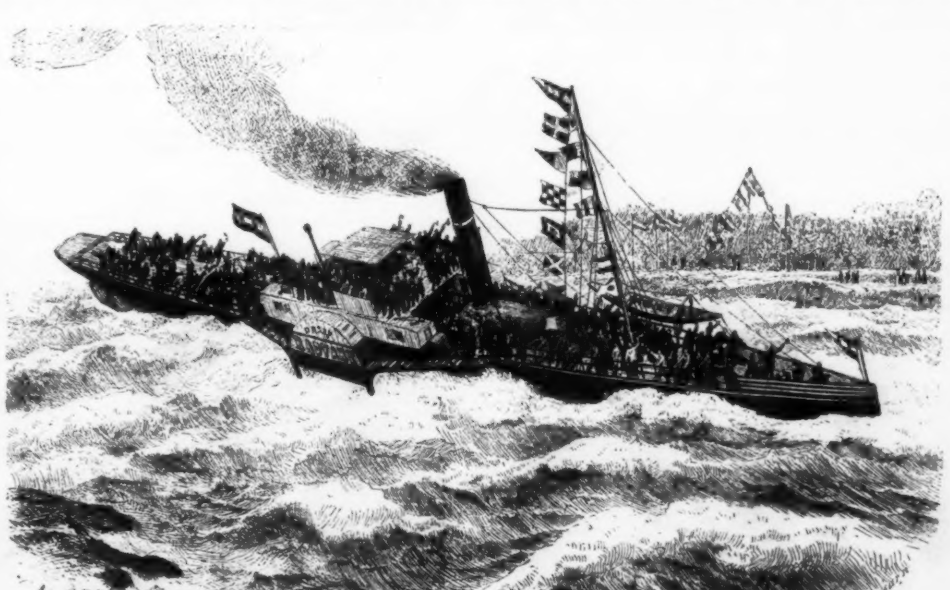
THE WORK OF IMPROVING THE DANUBE.

Some years ago the Hungarian government undertook a series of methodical operations with the object in view of rendering the course of the Danube regular. There are two reasons that served as a motive for this work. In the first place, it is of interest to facilitate navigation upon this beautiful river, which, merely in the part traversing Hungary, has a length of 575 miles. Now, the sinuosities of its channel, which in addition is constantly shifting, expose ships to incessant detours and sometimes to delays or stranding. In the second place, from time immemorial, the Danube has exposed the regions through which it passes to terrible inundations, some of which have left painful remembrances. We shall not speak at present of the important work on the celebrated channel of the Danube called the "Iron Gates." The object of this work, recently begun and actively prosecuted, is to free the bed of the river of a very hard rocky barrier that obstructed it. This is a special and isolated case of the general programme. The works that we shall speak of to-day, and the different episodes of which are shown in our engravings, consist in diking the river and giving it a uniform and invariable width of 300 meters. Moreover, the too pronounced bends that are met with are intersected by the channel so as to shorten the way for navigation in avoiding the sinuosities resulting from them. Of course, the engineers profit by this occasion to dredge the bed of the river to a uniform depth and to render its slope regular. It was necessary to divide the putting in execution of this important work into several sections. The first credit of 34,000,000 francs, voted by the Chambers, was devoted to rendering regular that part of the river comprised between the frontier of Austria and the market town of Deveny and of Duna-Radvany, at 11 miles below Komorn. In this section the Danube has a length of 87 miles. The work of straightening this part, comprised between miles 7·75 and 75·5 of the general plan, was begun in the spring of 1886. It is now nearly finished. The 300 meter channel has been diked, dredged and fixed. Moreover, eight bends of the river have been cut off at points where they presented an exaggerated development or where, as shown in our engraving of the part inaugurated on the 22d of October last, they traversed a true meander of small canals surrounding innumerable islands or islets. The excavation of the channel at Jarfalu was one of the most difficult phases of the operation. It was accomplished with remarkable precision through the use of methods new and original in the art of public works. We shall enter into a few details on the subject of them. As our map shows, the engineers utilized, as far as possible, the course of the Danube itself in their direction line, which, by the rational study of curves and gradients, recalls that of a great railroad line. When they had to deal with the principal arm of the river, they narrowed it to the adopted width of 300 meters by diking it in its very course. If there was a question of utilizing a small arm, it was widened through dredging. Finally, where the direction line required it, in order to preserve the regular and methodical velocity, the engineers boldly cut through the islands, fields and forests. The construction of the dikes presented no peculiarity except their unusual length. They were executed by the ordinary processes of earthwork wherever the ground presented no special difficulties. On the contrary, a very original process was brought into play for widening the arms of the river utilized, but having an insufficient width, and for the cutting off of the bends having a great inflexion. With remarkable sagacity, the engineers made the Danube itself not only render its new bed regular and deepen it, but also fill in the dikes established in order to render it regular. This method, of which the various phases are represented in our engravings, is as follows: Let us place ourselves in the case where there is reason for prolonging the channel by widening a small arm partially utilized and rectifying the projections of the banks. To this effect, the dikes are in the first place prolonged in the alignment indicated by the plan, as well upon *terra firma* as in the bed of the river when one meets it, or else are raised to two meters in height with a width of two meters upon *terra firma* solely after it has been cleared of trees. The future bed of the river is thus traced upon the land and diked. It remains to deepen it and clear it of everything that might obstruct it. By means of strong dams above the section, all the secondary arms, aside from the one utilized, are blocked up, and the entire discharge of the river is forced to pass through the narrowed section of the new channel. There results a strong current, owing to which the water, by its very live force, deepens the bed, removes the projections of the banks and, in a word, accomplishes with rare power and rapidity a work that by the usual processes of dredging or earthwork would be at once lengthy, costly and troublesome. The excavation thus effected by the river is not accomplished, of course, without quite a large portion of the dry stones of which the dikes are constructed being torn away. These stones simply fall to the bottom of the talus that forms the banks of the new channel and constitute a sort of rockwork there that assures the stability of them. The engineers, therefore, have on the whole, merely to slightly complete the construction of the dikes and stop up a few holes, after the



MAP OF THE CANALIZATION OF THE DANUBE, BETWEEN VAIKA AND REMETE.

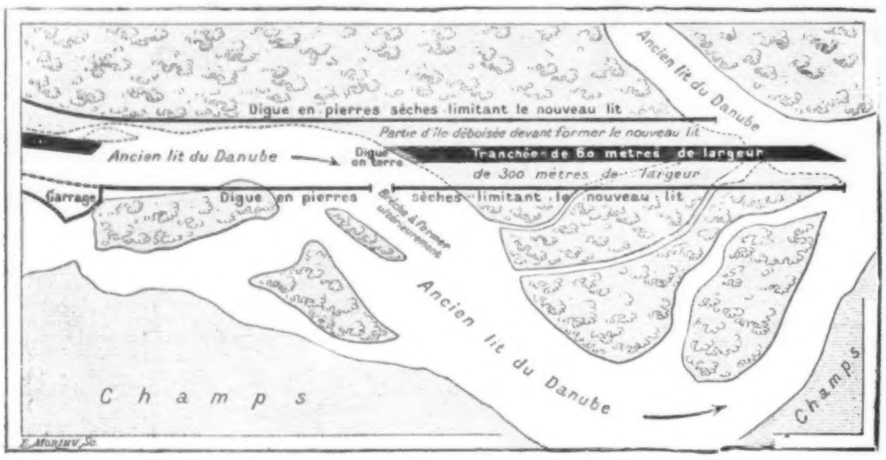


THE STEAMBOAT RADVANY ENTERING THE NEW BED OF THE DANUBE.

powerful current, which serves them as a colaborer, has accomplished its work.

As for the earth, sand and mud that the current carries along, and which might obstruct the river bed upon depositing, there is opened to them here and there downstream a sort of gate from 50 to 100 meters in width in the dike. These breaches correspond to the small condemned arms. The muddy stream flows into these, deposits therein and fills them up. The Danube has thus completed its work by depositing at the desired point the materials that it has torn away in the first place in order to open up and deepen its new channel.

We have said that one of the most curious episodes of this great work was the cutting of the pass of Jarfalu, at 1¾ miles above Presbourg. The abolishing of the bends was begun, in fact, in starting from the lower extremity. That of Jarfalu bore the number 8. At this place the river ramifies into a host of small arms, through which navigation had to pick its way.



THE PART OF THE WORK INAUGURATED OCTOBER 22, 1893.

ONE OF THE LONGITUDINAL DIKES OF DRY STONES.

Moreover, it presented a sill upon which, during severe winters, blocks of ice became frequently piled. The water, arrested in its course, rose behind this obstacle and flowed back toward Presbourg and threatened its security. The straightening effected will do away with such inconveniences and dangers. At the place indicated, the old bed of the Danube, the principal arm, has a width of about 700 meters and describes an irregular arc of a circle, the chord of which is sensibly figured by the new channel, 1,960 meters in length. The grade in the old bed is 39 centimeters to the kilometer. The new channel will have a grade of 67 centimeters to the kilometer, thus giving between the two extremities of the Jarfalu section a change of level of 1·33 meters.

For such straightening, as we have already stated, the Danube itself was utilized. Here is how: The new channel traversed in its passage a wooded island that it was necessary to cut into for a width of 300 meters. A beginning was made by clearing this island of trees, etc., over this entire width. Then, as shown in our engraving, the earth was removed to a depth of one meter over a width of 60 meters in the alignment. Afterward, the water was allowed to enter, and the floating dredger deepened the channel to two meters below the zero of the scale.

An approach was thus made to within 22 meters of the old bed of the Danube, which was separated from its new bed by a sort of natural dam remaining in the island. There was nothing further to do but to allow it to tear away this barrier and finish the work of the engineers. This operation gave rise to an imposing solemnity.

The high society of Presbourg was invited on the 22d of last October, by the direction of the enterprise, to see the Danube take possession of its new bed. Royal Councilor Alexander de Keczkes, of Ganocz, presided at the ceremony, assisted by M. Banlaky, engineer in chief.

As shown in our engravings, a tongue of land separated the majestic Danube, all inflated with its force, from the cutting that was to guide its route in the conquest of its new domain. At ten minutes past eleven, M. Banlaky gave the signal by removing a shovelful of earth. A force of laborers, spade in hand, made a trench in the dams established in the island and which closed the four cuttings made from one side to the other.

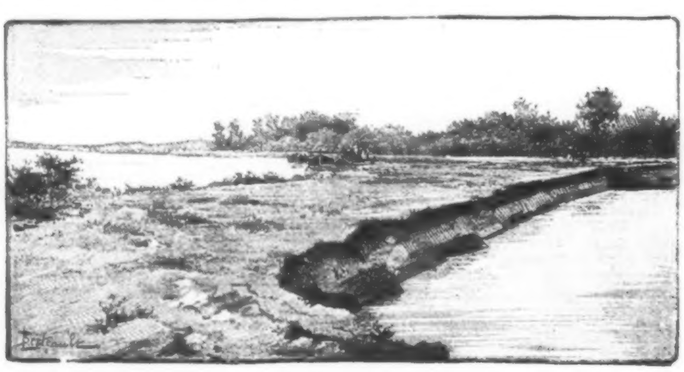
At a quarter past eleven thin streams of water began to infilter through the dams. At half past eleven the frail barrier was broken. Small cause, great effect! In a few minutes, the Danube, quickened, found its way. A muddy stream flowed from each of the little cuttings, and the first rowboat was able to effect its passage between the old bed of the Danube and the new channel. And the island that barred the route was seen to be washed away and disappear under the torrential action that kept ever increasing.

At ten minutes of one, one of the islets isolated by the trenches, the most friable islet, had disappeared. On board the steamboat, the passengers saluted jovially, in drinking the excellent wines of Hungary, the breaking away of the natural dam.

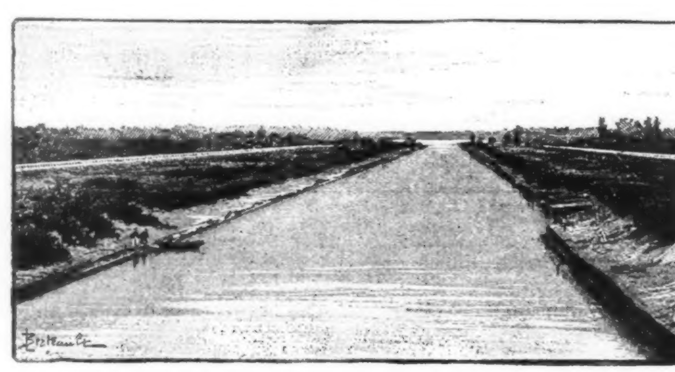
The Danube, as if proud of its work and impatient to finish it, tore away and devoured everything that resisted it.

At forty minutes past one nothing remained intact except the last islet. This the river attacked and undermined, and at ten minutes past two it had disappeared.

Upon the spot where the island was that morning



DAM SEPARATING THE PROVISIONAL CUTTING FROM THE PRINCIPAL BED OF THE RIVER.



PROVISIONAL CUTTING OF THE NEW BED OF THE DANUBE.

THE FIRST INFILTRATIONS.

THE PASSAGE OF THE FIRST ROWBOAT.

rooted in the earth there was now a rapid nearly two meters in depth, forming a formidable current, effecting in a few minutes what could not be done by an excellent dredger in a day.

The engineers had promised themselves to triumph to the end. With a confidence in themselves that did them honor, at twenty minutes past two, three hours after the first blow of the pick given by M. Banlaky, they permitted the steamer Radvany to blow her whistle, merrily leave her mooring and intrepidly cross the rapids to enter victoriously into the new channel. . . .

At the hour at which we write, the Danube is automatically pursuing its work. The width of the new bed that it is increasing, deepening and shaping at the will of its power already exceeds 100 meters. During this time one is proceeding with the finishing of the dikes and necessary works; but steamboats and lighters can now pass without impediment by the direct route.—*L'Illustration.*

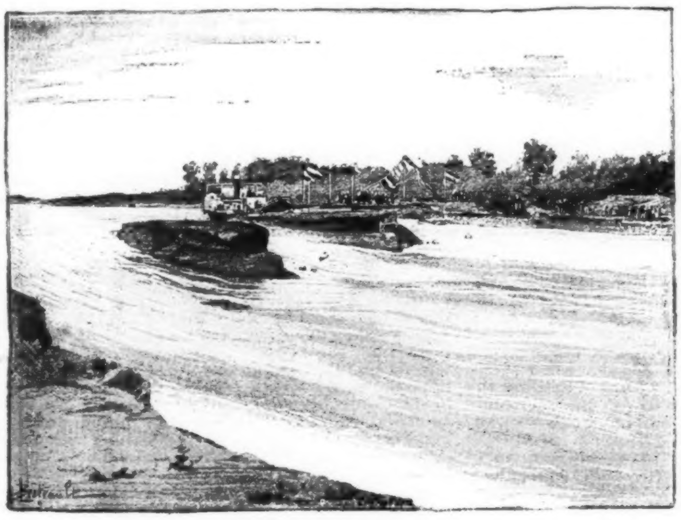
ARTESIAN WELLS AS A SOURCE OF WATER SUPPLY.*

By Prof. ERASTUS G. SMITH.

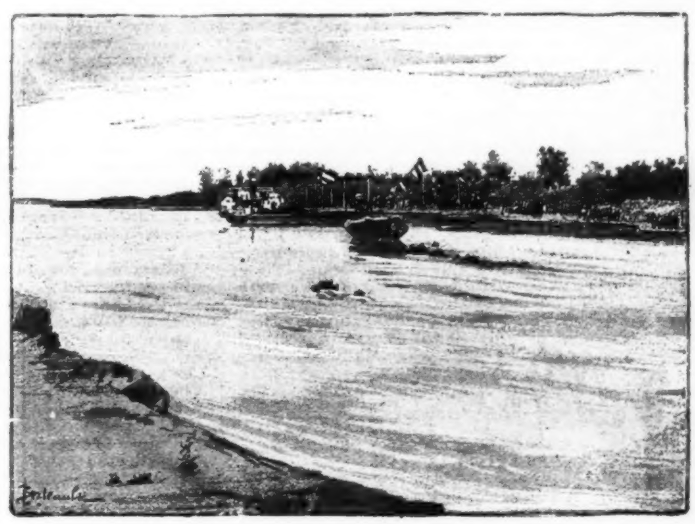
A GIFTED and usually very sensible writer on the manufacture of paper has written one very senseless sentence: "Boring an artesian well in an untried place is like digging for hidden treasure, a very uncertain undertaking." I indorse the writer's sentiment if by it we are to understand a random, happy-go-lucky, hit-or-miss style of boring and exploration, with no chart or compass to give the proper bearings, trusting that we may hit something somewhere below in the depths of Mother Earth, and that smiling Fortune will crown our misguided efforts. Capital so invested and energy so misdirected usually reap the just harvest of their own reckless seeding. But it can hardly be affirmed at the present time that the study of the deep artesian well service is a new field of investigation, or that data are wanting regarding it which may not be of rich service in properly determining the course of action over a reference. Every student of water supply is more or less conversant with the principles involved, but in order that we may have definitely in mind just these principles of artesian wells to make more clear what I may say a little further on, I will simply allude to the conditions controlling an artesian flow, allowing you to fill in the details as your individual study and experience may suggest.

ESSENTIAL GEOLOGICAL CONDITIONS OF ARTESIAN WELLS.

The artesian well has its source, its downward underground course, and its ascent through the well. Picture to your mind a pervious stratum through which water can readily pass. Below this let there be a water-tight bed and a similar one above. Suppose these layers come to the surface in some elevated region, and then pitch downward in some direction to considerable depth, and then come up again at some distance, thus forming a great basin, or else terminate in such a manner that water cannot escape in that direction. Now let rainfall and surface waters fill this porous stratum full to the brim. It is evident that if this stratum full of water and under head be tapped at any lower level, the water will rise in the bore and be discharged from the opening, this continuing so long as supply will equal the demand of the bore. Or to formulate distinct propositions from this simple conception, the essential requisites are: A porous stratum to receive and permit the passage of the water; an impervious stratum below to prevent escape of the water downward; a like impervious stratum above to prevent the escape of the water from the bed upward; an inclination of the strata, so that the edge where water enters may be higher than at the surface of the well and give the head; a suitable exposure of the edge, preferably with a covering of porous sand or gravel, to form a collecting area sufficient for the supply of water; an adequate rainfall to furnish this supply, and an absence of any escape for the water at a lower level than the surface of the well. Without going further into the general conditions or the details affecting them and thus controlling the supply, this annunciation of the simple geological principles will serve to fix this class of well distinctly in mind.



THE DISAPPEARANCE OF ONE OF THE ISLETS.



THE DEBRIS OF THE LAST ISLET.

good share of our territory, or lend their value and assistance in pushing such ventures to a rational and successful conclusion.

The term "artesian well" has unhappily become somewhat confusing. Strictly speaking, it should be applied only to such deep wells as are bored through impervious rock strata to a porous water-bearing rock stratum, whence the water flows to the surface and is discharged from the bore. The term has come into very wide use, and has been applied to many classes of wells, even some of the shallower pipe wells merely driven a few feet into sand and gravel being very improperly called "artesian wells." It is almost necessary, however, to retain the use of the term "artesian" for such very deep wells as pierce impervious strata to free porous water-bearing strata, whence the waters rise to within a short distance of the surface, even if there may be no real flow established. Such a well is an artesian well to all intents and purposes, and as such I think it fair to include in our discussion. The study of these artesian wells is a legitimate and necessary field of study for the hydraulic engineer, as at so many points at the present are they under consideration as a source of water supply for public service. This study includes two quite separate and distinct fields—the purely geological study and the purely chemical study.

The first of these divisions I shall pass over at this time, as the full explanation of these conditions lies in the geological field, and the engineer who would intelligently approach the study and who would expect to successfully and economically develop a deep artesian well at any locality with credit to himself and the complete satisfaction of his patrons, must avail himself of the services of the geologist who may in his judgment be most familiar with the topography and stratigraphy of the particular region. The particular conditions must be thoroughly studied on the ground and made as intelligible as possible by a mastery of the general conditions controlling artesian wells. I would like to refer members of this association to an article on "The Requisites and Qualifying Conditions of Artesian Wells," in the fifth annual report of the U. S. Geological Survey, written by Prof. Thomas C. Chamberlain, which is probably the most succinct and clear exposition of these general conditions; also to an article by the same author in "Geology of Wisconsin," Vol. I. The first article especially should be on every hydraulic engineer's shelf for ready

* A paper read before the American Water Works Association at Milwaukee, Wis., September, 1893.

SOME CHEMICAL FEATURES OF ARTESIAN WELL SUPPLY.

This is distinctively the chemical side of the problem of artesian wells. The quality of a water is the gravest question for the consulting engineer to adjust in his determination regarding the best available local supply for a public system. The term pure water is fast disappearing from the specifications of engineers and guarantees of franchises. Experience has taught us not to guarantee the impossible, and a pure natural water is an impossibility. It is counter to all theories and expectations that we shall find such a commodity as pure water. It may be good and wholesome, but never pure. Our artesian source does not differ in the least in this respect from our surface waters. In fact, we may almost say that many troubles we meet with in surface waters are in artesian wells doubly intensified. I think we may lay it down as a general principle that we may expect in artesian water a great increase in saline matters over our ordinary land waters for the same locality. There are some notable exceptions, one of which will be noted further, but as a general rule I have found our deep artesian well waters heavily loaded with saline matters. If any of my hearers have had occasion to canvass thoroughly the advisability of our artesian supply at any point, and in connection with that study may have collected any considerable number of chemical analyses of waters from deep artesian wells, he has I am sure been perplexed and bewildered by the returns received, until in despair at hope of securing any intelligent data which would be of use in determining the problem in hand, the whole undertaking may have been abandoned.

This confusion regarding the quality of water from artesian wells arises from our imperfect knowledge of the strata whence the flow comes. The analysis may be perfectly true and may give us a true knowledge of the quality of the water the well furnished and be of great value to all parties; but as an indication of what we may find elsewhere or as an index of the quality of water we may expect in that section, it is worthless, because we do not know the strata whence the flow is established. It is absolutely essential in using such data intelligently that we have the complete record of the well; its depth, the strata traversed, their thickness, the water-bearing strata, their relative thickness, abundance of flow and quality of same, before we can rightly use that well as an index for other borings. And yet in how many wells is any such record kept? We know the depth of the well, the character of the final flow, and little else. You can see at once the significance of this condition. A thin layer of limited extent containing saline matter is traversed; this is mingled with the main stream coming from below, and imparts a distinctively saline character to the whole. This localization of saline strata produces most confusing results—*e. g.*, an artesian well in Illinois, 1,300 feet deep, the water from which submitted to me gave 88 grains of solids to the gallon. A well 7 miles away and 2,100 feet deep gave 31 grains to the gallon or, roughly speaking, only one-third as much. Well No. 1 is useless, well No. 2 fair.

The confusion arises also because thus an attempt is made to compare waters from absolutely different strata, and therefore of probably radically different character. Waters from the same strata, however far remote the wells may be, are usually of essentially the same character. This is what we must expect from the very conditions of artesian wells, and what is well defined conformity is the case. Marked deviations are, I am sure from observation of the waters discharged, due to infiltration from other strata insufficiently cut off and plugged back. The practical side of this consideration should not be lost sight of by this convention. It is safe to assume that when water from one stratum has been proved to be good that elsewhere we may expect the same quality of water, if only we may be able to strike into the same stratum and then sufficiently protect that stratum from degrading infiltration from other strata traversed above.

It seems to me that we can make this whole matter very clear if we can follow one series of artesian wells somewhat in detail. The whole Mississippi basin furnishes us with the very best examples of artesian service in this country. Other localities give also a good artesian service, and many other wells furnish an adequate and good quality of water. Among the very best defined artesian wells of the Mississippi basin are those springing from the Potsdam sandstone. If you will recall the conditions for an artesian well, you will find them very typically illustrated in this layer and a most splendid field for the intelligent study of the whole problem.

The Potsdam sandstone crops out in Wisconsin, its lower edge being around Portage, about 30 miles north of Madison, and running in an irregular crescent shape across the State. Its greatest width is about 50 miles, and the area covered is upward of 12,000 square miles. The stratum then dips somewhat to the east of south, passing under southern Wisconsin and reaching to unknown distances south. This bed is upward of 1,000 feet in thickness. In texture it is a loose, porous sandstone with thin beds of shale and limestone irregularly traversing it. The confining impervious stratum above is the magnesum limestone, the Potsdam resting directly upon the old archæan and granitic formations. The exposed edge of the Potsdam in Wisconsin is channeled and furrowed by watercourses, and is overlaid

LOCALITY.	Date.	Depth.	Potassium Sulphate.	Sodium Sulphate.	Sodium Chloride.	Sodium Phosphate.	Sodium Bicarbonate.	Magnesium Bicarbonate.	Calcium Bicarbonate.	Calcium Sulphate.	Iron Bicarbonate.	Alumina.	Silica.	Total.
Madison, Wis	....	1,015 feet.	0·024	0·29	0·219	Trace.	1 00	12·98	15·24	..	0·021	Trace.	0·42	30·76
Janesville, Wis	1887	....	0·116	0·408	0·489	"	....	12·664	12·045	0·314	0·087	0·098	0·536	26·75
Whitewater, Wis	1889	957 feet.	0·14	....	0·86	"	...	11·58	14·57	0·53	0·16	0·04	0·47	28·35
Burlington, Wis	1889	1,008 "	0·56	1·08	0·46	"	....	8·89	12·10	2·46	0·03	0·03	0·40	26·01
Rockford, Ill. Well No. 1	1885	1,530 "	0·52	0·52	0·36	"	....	12·79	13·18	....	0·07	0·05	0·62	28·11
Rockford, Ill. Well No. 2	1886	1,320 "	0·52	0·31	0·34	"	0·41	12·85	13·15	....	0·09	0·10	0·05	28.82
Rockford, Ill. Well No. 3	1886	1,996 "	0·50	0·35	0·27	"	0·81	12·79	13·17	....	0·07	0·13	0·58	28·67
Dixon, Ill	1889	1,600 "	0·07	0·75	0·27	"	....	12·16	14·04	0·17	0·07	0·09	0·77	28·39
Sterling, Ill	1886	1,450 "	0·46	0·54	0·69	"	....	13·35	14·85	....	0·06	0·06	0·61	30·64

with a more or less thick layer of drift sand and gravel. The very ideals for an artesian service are thus realized; the broad, spongy collecting area, the downward inclination of strata, the confining impervious beds, the porous, sandy, transmitting stratum. All geological conditions indicate a probable flow at points where the level of the orifice of the well is sufficiently below the level of the collecting area in Wisconsin. What is the quality of the water and how may the data be used in studying other prospective supplies for this great region above the Potsdam sandstone?

The source of the water supply is primarily the rainfall on the collecting area. This water thus originally essentially a pure water will contain such mineral salts in solution only as the waters may meet and traverse in their course downward through the superficial drift and the deep strata. I can fortunately offer for your study nine full analyses of waters from the Potsdam sandstone, concerning the integrity of which I have absolutely no question as being true Potsdam waters, and efficiently cut off from infiltration from other strata. It will be noticed that these wells are in an almost straight line north and south and follow essentially the dip of the sandstone. All of these analyses, with the exception of the first one, were made by myself at different periods.

In addition to the above table, I can add the following data regarding these Potsdam waters, when only partial analyses were made the solids being given in totals merely:

Locality.	Depth.	Date.	Total Grains per Gallon.
Rockford, Ill., Well No. 4 .	1,300 feet	1891	17
From five wells combined . .	1,530 "	1891	
" " " "	1,320 "		
" " " "	1,996 "		19·3
" " " "	1,300 "	1891	20·0
" " " "	1,379 "	1891	20·0
Graham's Mill.	1,400 "	1891	17·8
Princeton, Ill.	2,500 "		23·7
Belvidere, Ill.	1,932 "		16·7

I will not add to this list of analyses in this connection, as it seems to me perfectly clear from these already given that the waters yielded by this stratum at different periods and from different levels are practically uniform in character. This is what we should expect, as it is quite counter to the theory and practice of solution that draughts from different points of the same reservoir should give a fluid of essentially different constitution.

The second general principle regarding the waters from artesian wells can, I think, also be best understood by a special case, and for this purpose I will again take the Potsdam sandstone. It seems safe to assume that we may regard about 28 to 30 grains of solids calculated as in above table as the normal constitution of true Potsdam water. But other waters represented as coming from Potsdam sandstone give quite other results, of which I will cite a few typical cases, from analyses collected from various miscellaneous sources, but not verified by the analyst or check analyses.

Locality.	Depth.	Total.	Alkalies, Sulphates, Chlorides, and Carbonates.
Woodstock, Ill	1,300 feet.	39·9	15·09
Monmouth, Ill	1,227 "	73·8	42·62
Rock Island, Ill.	1,100 "	67·3	51·0
Davenport, Ia	2,150 "	60·1	38·0
Clinton, Ia	1,674 "	38·8	18·0
Kenosha, Wis	1,365 "	36·02	12·2

Many others might be given, some of them with even greater differences than these, but what I wish to call especial attention to is this: That the Potsdam water contains normally about 28 to 30 grains per gallon of water, of which only about 1·0 to 2·5 grains are the soluble salts of the alkalies, *i. e.*, the sulphates, chlorides, and carbonates of potash and soda, leaving roughly about 26 grains of the other mineral matters, mostly the bicarbonates of lime and magnesia. In these cases cited there is a marked increase in solids, but that increase is due to an increase of the soluble alkaline salts. The carbonates of lime and magnesia are usually somewhat diminished, being changed into the corresponding sulphate. To explain and account for these deviations we are therefore forced to one of two conclusions—either the data furnished by some analyses are incorrect or waters from some points of the Potsdam sandstone are subject to local variations. The first conclusion we will dismiss here, as many of the analyses are by men of acknowledged skill and reputation in the analysis of waters.

The second perplexing proposition finds its answer, it seems to me from my study of these wells, that while the water from the sandstone is true Potsdam, it has been materially altered by infiltration from the superincumbent strata which the drill has traversed and the infiltrations from which have not been sufficiently cut off or plugged back. I am not sure that this view will meet with the unqualified indorsement of all present, but it seems to me perfectly reasonable and to meet the case. In support of this view, I would note that in drilling a well it is well known that many smaller water-bearing strata are traversed. None of them probably may come to the surface, but the waters would seep out and work out into the bore. When the head of the Potsdam strata was pierced and a flow established, we cannot expect that the water rushing up the bore would by its own momentum plug back completely all superior infiltrations, but that rather they would be borne along with the water. Admit this principle once, and deviations in our Postdam supply are explained.

When the essential features for a true artesian flowing well are recalled, conditions can be conceived where such superior filtrations would be improbable, *e. g.*, where in such superior strata their pressures and textures are such that the waters from the Potsdam under greater pressure find a partial escape along them. But in many true flowing wells it can be conceived how this infiltration would be perfectly true, and especially is it true for the great number of deep wells called artesian and used for a supply included also under this discussion, when waters do not rise fully to the surface, but are pumped. It is further a matter of common experience to those studying the artesian supply that wells are thus frequently plugged either above or below a given stratum, thus cutting off undesirable waters and improving the quality. And finally we note that as we go further south and southwest on the Potsdam supply the waters become more and more saline in character, or as we approach the coal districts the alkalies and the sulphates become more permanent.

I have dwelt thus at length upon the Potsdam sandstone supply, because, in the first place, I was personally more familiar with it, and secondly, because it has been so carefully studied that I deemed it the best method in which to clearly present to this body the principles underlying the study of wells and the laws of probabilities controlling them. We might repeat this study with good results in the great stratum known as the St. Peter's sandstone, and would arrive at very similar conclusions. Apply the study to general true artesian supply, and we will find the trouble and perplexity greatly diminished if we search diligently for the true strata water and distinguish carefully between it and the foreign infiltration. A second source of perplexity in our study will be removed if we do not confound our true artesian service where waters flow or rise under head in the bore with simple bored wells, or, worse than all, mere drift-driven wells; in both latter cases we are dealing with quiescent waters, non-comparable with those from the deeper strata and under head. With these last two classes of waters this paper does not deal.

While it is true our sandstones furnish our best artesian supply, and their study essentially covers the study of the artesian service in the Mississippi basin, flowing wells are occasionally obtained from other strata and even from the drift. The characters of the waters then partake of the character of the matrix—in the case of a limestone becoming more heavily charged with lime and magnesia, and in the case of drift becoming merely a modified surface water.

As compared with surface waters, it will usually be found true that the deep artesian waters are more heavily loaded with saline matter. We do not expect to find an artesian water with much under 30 grains of solids per United States gallon (with lime and magnesia calculated as bicarbonates). About the same amount fairly represents our best surface waters. Rivers and streams contain less and the lakes least of all, Lake Superior heading the list with two to three grains of solids per gallon of water. In artesian wells the dissolved solids rise rapidly to amounts giving the waters a distinctly saline taste and forbidding their use for a general supply. For other sections of the country others must speak authoritatively. Some analyses made at the Beloit laboratory from artesian wells along the Gulf of Mexico would indicate that there the waters are feebly alkaline and are superior to even our best artesian waters. Analyses from artesian wells at other points are too sporadic to justify us in drawing at present conclusions therefrom.

There is one other important feature regarding the constitution of deep artesian waters to which I would call the attention of this convention, and this is by the significance of a sanitary analysis of water as applied to these deep artesian wells. There is no competent engineer or water works manager but has an idea in a general way regarding the data furnished by a sanitary analysis of water. This aims to give such data as may lead to some accurate conclusions regarding the presence and amounts of organic matters in water and the consequent healthfulness or unhealthfulness of a supply. The data usually required are the volatile residue, fixed residue, total residue, hardness, chlorine, oxygen consumed after various intervals, and especially the condition of the nitrogen as shown by the albuminoid ammonia, free ammonia, nitrous and nitric acids. One unanswerable argument in favor of artesian wells hitherto advanced has been their positive freedom from organic and surface waters and sewage. The very conditions for an artesian well—deep, impervious, superimposed strata—seem to favor the idea. In the actual demonstrations to prove the presence or absence of organic matters, the methods of the sanitary analysis of surface waters have been quite widely applied. There may be no objection to this study of the waters, but I am sure that we will be led into serious error in formulating an opinion, unless extreme care is taken regarding the correct interpretations to be given to such analyses. I have made several such whole or partial sanitary analyses of artesian waters, and have collected some made by others from these wells. These almost, without exception, fall into one of two classes. Those where the data are reduced to almost zero in each determination, and therefore show the absence of organic matters; those where the analyses show some astounding amounts in one determination, notably in the amount of free ammonia.

In the first class are found our free Potsdam sandstone waters, and probably our St. Peter's sandstone waters, leaving little to be desired in the matter of purity, according to accepted standards, and with this word may therefore be dismissed. It is the second class I wish to call special attention to at this time, as the results obtained are so abnormal, and reports based on these data have been made regarding such wells positively condemning them. So far as I know, the literature of the analyses of water supplies is silent on these particular conditions, save an occasional fugitive allusion, merely citing the fact of the presence of a large amount of ammonia.

In a paper read before the American Association for the Advancement of Science, at Madison, last summer, on "The Occurrence and Distribution of Nitrogen in Deep Artesian Wells," I called the attention to those peculiar conditions and phenomena and will introduce one table used at that discussion. The analyst or hydraulic engineer who may have had much experience with these deep wells will have noticed the extraordinary amounts of free ammonia some of them show; in fact, so much that our ordinary methods of estimating it are almost worthless. But as significant is the fact that while the free ammonia is so high, nitrogen in all other conditions, as albuminoid ammonia, nitrous acid, and nitric acid, is wanting. This is quite contrary to what we would expect or do find almost without exception in surface waters. To make more clear this peculiar condition of the nitrogen, I will make ten such analyses of waters from the artesian wells made at the Beloit Laboratory which are selected as well illustrating the phenomena:

Locality.	Depth.	Total Solids Grains Per U. S. Gallon.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Whitewater, Wis.	315	16·7	0·15	0·01	0·00	0·00
Massillon, O.	208	15·4	0·45	0·01	0·00	0·00
Chicago, Ill.	400	13·6	0·26	0·07	0·00	0·00
Van Wert, O.	53	93·5	0·52	0·03	0·00	0·00
Van Wert, O.	98	93·9	0·59	0·02	0·00	0·00
La Grange, Ill.	2,100	31·6	0·40	0·05	0·00	0·00
Peru, Ill.	1,300	49·5	1·08	0·05	0·00	0·00
Hillsboro, Ill.	400	39·1	1·20	0·01	0·00	0·00
Harvey, Ill.	1,300	88·0	0·90	0·00	0·00	0·00
Davenport, Iowa.	1,067	73·2	0·90	0·01	0·00	0·00

The study of this table develops some noteworthy observations. The enormous amounts of free ammonia; the trace of albuminoid ammonia so low as to suggest whether it really is not accidental or free ammonia, only expelled after the addition of the strong alkaline permanganate solution added to develop the albuminoid ammonia; the absence of nitrites and nitrates. The presence of any such amount of free ammonia in any such surface water would be viewed with grave suspicion, if not positively condemned, and application of these same standards to the artesian wells might lead to condemnation.

It is to be specially noted, however, that we have the nitrogen all aggregated into the one form of ammonia and not distributed through the four forms usually met with, and I think it becomes remarkable and attracts attention, because thus aggregated into the single form and not distributed through the four forms. A simple calculation of the nitrogen changed into and distributed through these usual forms would show it to fall well within our accepted standards for maximum impurity of waters.

The fact of so much ammonia so often found in these deep waters, its significance and cause, were to me for a long time a source of perplexity and anxiety on being required to pass a correct opinion on their sanitary nature. The samples had been very carefully collected in my own glass-stoppered bottles; thoroughly cleaned before leaving the laboratory and protected from intruding ammonia on return. Duplicate well-checking analyses from different bottles proved that the amount of ammonia truly represented the ammonia normally present in the water. A chance visit to one of the wells revealed the presence in traces of sulphureted hydrogen and suggested a reasonable explanation of the difficulty. Personal inspection of seven of the wells in the above table expressly to determine this point, and correspondence regarding all others containing high ammonia coming under my observation have shown the presence of this sulphureted hydrogen in the waters. So that the extraordinary ammonia can be explained on the basis that the sulphureted hydrogen has exerted its well-known reducing action, either reducing the higher oxidized compounds of nitrogen back to ammonia or preventing entirely their formation. This explanation seems to me perfectly satisfactory and reasonable. It may be that other agencies, as the iron oxide dissolved in these waters, also lend their assistance to the final result, but probably the sulphureted hydrogen is the principal one at work.

On this basis of explanation it is fair to question whether any amount of ammonia up to 1. + per million at least has any significance for these deep wells. This is the practical point I wished to develop to this body of practical men. You can see at once how our ordinary standards of maximum impurity (*e. g.*, 0·08 free ammonia per million) utterly fail when applied to any such data as are cited above. The above explanation has satisfactorily met all cases coming thus far under my observation, and it will be a matter of great interest to see whether it may coincide with the experience of others and may sufficiently meet future inquiries and developments.

Regarding the gases present in these deep artesian wells, I would note the carbonic acid gas almost always present in the free state, and by virtue of which the carbonate of lime and magnesia are held in solution. Oxygen, according to the eminent analyst, Dr. Brown, of Boston, is always absent in these deep wells. Sulphureted hydrogen is very often present. It is, however, very elusive and disappears rapidly and wholly on relief of the waters from pressure and on aeration. In none of the analyses quoted above had I any suspicion of the presence of the gas when they reached the laboratory, and other analyses of artesian waters rarely make references to it.

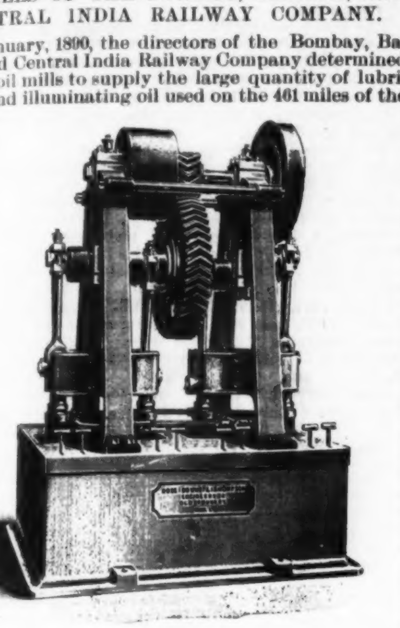
In conclusion, then, to briefly sum up some observations on these artesian wells, I would note:

1. The distinctively geological study and the distinctively chemical study it is necessary to give the problem in arriving at intelligent conclusions before advising or attempting developing an artesian service for a public water supply. 2. The confusion and perplexity which exist on collocating and comparing results of analyses of waters from other artesian wells, and attempts to intelligently and profitably use them. 3. The fact that waters from a given stratum are presumably of a practically uniform character. 4. That waters from such strata are materially altered by infiltrations from superincumbent or inferior strata. 5. In the application to the deep artesian wells of the method of sanitary analysis, as usually employed for classifying and properly valuing surface waters, care must be taken in the interpretation of results to arrive at correct views and knowledge regarding them.

These five points have been definitely in mind during the preparation of this paper, not that in any sense they exhaust the study of the water supply from our deep artesian wells, but with the hope they may form a distinct contribution to the resources of and may throw additional light upon one of the difficult problems of the engineer.

OIL MILLS OF THE BOMBAY, BARODA, AND CENTRAL INDIA RAILWAY COMPANY.

IN January, 1890, the directors of the Bombay, Baroda, and Central India Railway Company determined to erect oil mills to supply the large quantity of lubricating and illuminating oil used on the 461 miles of the



QUADRUPLE HYDRAULIC PUMPS.

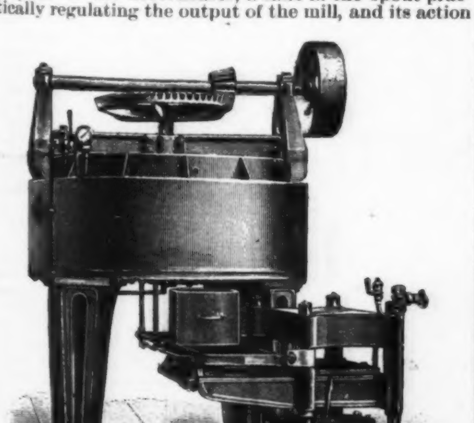
line now open. By the advice of Sir A. M. Rendel, K.C.M.G., the design of Messrs. Rose, Downs & Thompson, of the Old Foundry, Hull—subject to some modifications suggested by Mr. E. B. Carroll, the company's locomotive inspector—was accepted.

It was determined to erect the mills at Sabarmati, the transship junction between the broad gauge of the Bombay, Baroda, and Central India Railway Company and the narrow gauge of the Rajpootana-Malwa Rail-

HYDRAULIC OIL PRESS FOR 16 CAKES.

way, a convenient position on the company's system, and in a district well supplied with castor oil seed.

The process employed will be easily understood. The seed is delivered by rail to the mill premises, and stored in a go-down. The seed is conveyed in bags by a 15 in. gauge tramway to the sack lift, which raises it to a bin on the upper floor of the mill; from this it falls through a spout to the decorticator, a slide in the spout practically regulating the output of the mill, and its action



KETTLE AND SEED MOULDING AND MEASURING MACHINE.

is as follows: The thin, dark husk of the castor seed is cracked and separated, and the white kernel is used for the mill; the husk forms an excellent fuel.

The castor seed kernels are then pressed by the Anglo-American process as follows: The ground seed having been heated to about 100° Fah. in the kettle where it is damped and agitated, is withdrawn in charges by the moulding machine, where it is formed, measured, and given a preliminary compression. The "mould" of seed, now covered with a strip of woolen bagging, is placed in one of the presses. Each of these presses takes sixteen "moulds" of seed, and has a steel cylinder working at a pressure of 1½ tons per square inch. Under the first pressure about three-quarters of the oil is taken from the charge of each press. The cakes of compressed seed from these presses are then placed beneath the edge stones and reduced to meal, which is placed in an elevator by which it is put in a second kettle; from this it is withdrawn moulded and pressed in another block of presses. The hydraulic pressure for the presses and moulding machines is given by a set of quadruple belt-driven pumps, having four 3 in. low-pressure pumps, and the same number of high-pressure pumps 1½ in. diameter.

These pumps, which work a pair of accumulators, are fitted with automatic safety relief valves. The expressed oil is lifted from the tanks beneath the presses by the pumps, and is subsequently clarified by boiling. The oil is conveyed to the various stations on the line by tank cars, those on the Malwa-Rajpootana taking five tons, and those on the Bombay, Baroda, and Central India 10 tons at a charge. The castor seed husk is used for fuel and the cake for manure for sugar cane crops. The mill is also fitted for crushing linseed, a large quantity of this oil being required for the company's paint works.—*The Engineer.*

THE MANUFACTURE OF CIDER BY DIFFUSION.

LIKE all agricultural industries, that of the manufacture of cider has been notably improved within a few years. The *materiel*, the mills, the process, etc., have been so combined as to increase the produce and simplify the work. In even the most unpretentious cider manufactories hydraulic presses have been utilized. But a new method, very different from pressing, seems to be about to replace the extraction of apple juice in mills in Normandy and Picardy, and this is the method of diffusion, which has the advantage of giving a better and clearer cider and in larger quantity and also of easier preservation.

This method of diffusion consists in treating the cut or bruised fruit with water. The sugar and soluble principles pass by endosmosis through the walls of the vegetable cells, while the albuminoid substances remain undissolved in the cells. Upon the whole, the exhaustion of the valuable principles of the fruit is effected by water, and there is obtained a juice that is

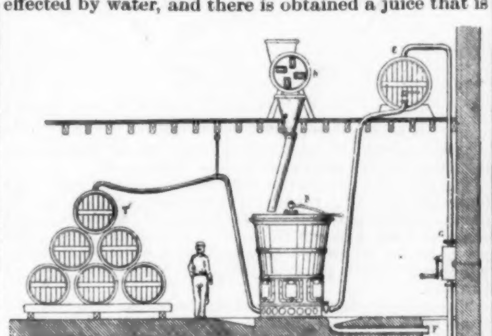


FIG. 1—INSTALLATION OF A CIDER MILL DIFFUSER.

as dense as if it had been extracted through pressure and that is less alterable.

In the old method, the pressure, in breaking the cells, causes the albumen to pass into the juice and this favors those secondary fermentations that are observed in cider, and that so unpleasantly alter the bouquet of it.

This method of diffusion, moreover, is already substituted for the method of rasping and pressing in the extraction of beet root sugar, and has given most remarkable results.

The diffusion apparatus for the preparation of cider differ but slightly from those employed for the manufacture of sugar; it is always the methodical exhaustion by water of the fruit bruised or cut into thin slices. Cold water is employed. Warm water exhausts better and more quickly, but affords a juice incapable of furnishing a savory cider.

We shall describe one of the diffusion apparatus most employed, that of Laforet. It consists of a battery of six metallic diffusers of cylindrical form movable around an axis actuated by a lever (Fig. 2). Each diffuser is provided with a door for the reception of the sliced apples. At the base there is a door for the removal of the exhausted fruit. A tube leads the water into one of the diffusers, and, thanks to a rotary motion of the battery, the water can enter into any one of the diffusers. Of the six diffusers, five communicate with each other, while the sixth is isolated and is empty or full during the operation, which must be continuous.

Through a second tube communicating with the fifth diffuser, the water charged with the apple juice, and which constitutes the wort, is capable of escaping into the casks in which the fermentation takes place, that is to say, the transformation of the cider.

The diffusers being charged, one introduces the water, which, having passed into the five compartments, reaches the exhaust tube with a density of from 1·040 to 1·045 for a velocity of flow of two quarts per minute with apples of medium saccharine richness. After a quantity of juice equivalent to the capacity of a diffuser has passed the apparatus is revolved, when the first diffuser will be put out of communication with the current of water. The sixth diffuser, containing fresh apples, will be put in battery, and will be the one through which the juice will make its exit, the second diffuser serving for the introduction of the water. The first diffuser is then to be discharged, and, if the operation has proceeded well, it should contain merely pure water and exhausted apples. The rotary motion is then continued, and, as far as possible, uninterruptedly day and night.

The juice, left to fermentation or mixed with cider barm (as one is beginning to prepare it in order to improve its quality), ferments well. The rackings leave little waste, and, moreover, owing to the absence of albumen, no lees form in the casks, as in the case of cider obtained by pressure.

FIG. 2.—A CIDER MILL DIFFUSER.

The product in cider of a density of 1·040 is about one pint to a pound of apples. In a large cider manufactory where this process is employed, the hydraulic press formerly used in the same works gave a product of but ninety per cent.

The method of diffusion may be applied upon a small scale, and the management of the apparatus is easy and practical.

Fig. 1 shows an installation with an apple cutter, *h*, and battery. The water, lifted from F by a pump, G, and discharged into a feed cask, E, circulates in the battery, B, and, converted into wort, enters the fermenting tuns, T.—*La Science Moderne.*

DOUBLE LEVEL WITH NEEDLES.

THE art of leveling, which, in our epoch, finds a more and more frequent application on account of the great works that the progress of science and the modern industries causes to be undertaken every day, necessitates instruments of which the rapid putting in place is in nowise prejudicial to the accuracy of the observations. The different instruments employed at present in geodesy have for base the spirit level, and all the operations tend toward the obtaining of a line parallel with the horizon.

The accompanying figure represents a level different from those constructed up to the present, and in which the horizontal line, entirely conventional and impossible to realize, is replaced by the vertical, the direction of which is absolute. This result is obtained by a new application of the principle of the Cardan suspension. In fact, up to the present, the Cardan suspension has been utilized only for maintaining in a fixed plane, vertical or horizontal, any object whatever (barometer, binnacle, compass, etc.), despite the oscillations of the external support. This mode of suspension consists, as well known, of two concentric circles, each suspended by pivots at right angles in pairs.

On the contrary, the apparatus under consideration utilizes the proper motions of the circles, which are replaced in the present case by small concentric hemispheres suspended also by pivots at right angles in pairs. The needles, one of them fixed to the center of

DOUBLE LEVEL WITH NEEDLES.

the internal hemisphere, and pointing upward, and the other to the summit of the external hemisphere, and pointing downward, indicate upon graduated semicircles, properly arranged in two planes at right angles with each other, by how many degrees the object that supports the level deviates from the

vertical, and starting from the horizontal, from front to back and from right to left. The graduation of the semicircles starts from the center, so that perfect horizontality is obtained when the two needles mark zero.

The distinctive character of this level is to fix, by a single motion, the horizontality of a plane by bringing the two right angle directions of the apparatus simultaneously at right angles with the vertical, while that with ordinary levels this operation requires two successive motions of the instrument, without counting the regulation of the bubble, which is always so lengthy and tiresome an operation, and always imperfect.

This little apparatus can be usefully applied to instruments of geodesy, surveying, leveling, tracing routes, etc., the putting in place of which will thus be effected with precision and sureness without changing the direction of the telescope.

At the lower right hand corner of the engraving is represented an application of the needle level, to which has been added a graduated sector placed beneath the lower semicircle and in the same plane. This sector, which is held by a binding screw, permits of giving the system as a whole any desired inclination, so that by the aid of this level it is possible to obtain a determinate gradient. Combined with an ordinary telescope, it would thus constitute a clisimeter, a clitograph or clinometer of high precision.

Placed upon any astronomical telescope provided with a reticule, the level thus completed at once makes an eclimeter of it. In fact, the upper needle indicates the zenith; the lower needle assures the horizontality of the perpendicular to the axis of the telescope; and the lower graduated sector, left free by the loosening of the screw designed to hold it, takes a position that shows, through a fixed datum point, how many degrees or fractions of a degree separate the zenith from the position of the star.

With slight modifications, artillerists might use it for the practice of firing. In any case, by means of this apparatus, one ought to reach a much greater precision than with the spirit level, since it determines the vertical in every direction through a single point—the extremity of each of the needles.

We think that this apparatus is susceptible of many other applications, and we have thought it of interest to make it known to the readers of *La Nature*.

STUDIES OF THE PHENOMENA OF SIMULTANEOUS CONTRAST COLOR; AND ON A PHOTOMETER FOR MEASURING THE INTENSITIES OF LIGHTS OF DIFFERENT COLORS.*

By ALFRED M. MAYER.

IT is often desirable in the study of simultaneous contrast colors to have large surfaces colored by contrast, so that we can the better match the colors of these surfaces with rotating colored disks and thus arrive at quantitative statements of their hues. This is especially desirable in ascertaining the hues of the light of flames, of the Welsbach incandescent lamp and of the arc electric light when compared with daylight, or when compared one with another. The result of many experiments is the apparatus described in the following section, and which is useful for this purpose.

Screen for ascertaining the hues of lights and the contrast colors of these lights.—A ring is formed of white cardboard by cutting out a central opening of 12 cm. in diameter in a disk of 22 cm. in diameter. This ring has a breadth of 5 cm. Another ring is made similar to this one, except that it has four narrow radial arms to support a disk of thin translucent *white* paper,† 35 cm. in diameter. This paper disk is placed between the rings, which are then fastened together and screwed to a thin rod, on a stand as shown in Fig. 1.

Place the screen, thus formed, in front of a petroleum lamp and exclude the daylight from the side

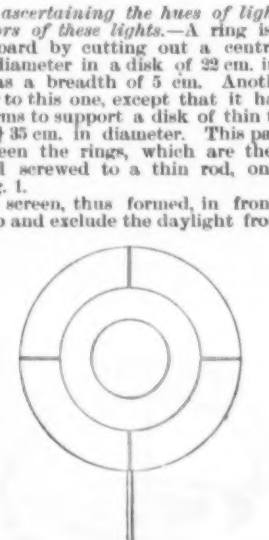


FIG. 1.

thus illuminated. The other side of the screen is illuminated by the light of the sky admitted through a distant window. The cardboard ring is thus illuminated on one side only by the lamp; on the other side, only by the daylight. The translucent paper transmits the lamplight to the side facing the window, while it transmits the daylight to the side facing the lamp. On the side of the screen facing the window the cardboard ring appears cyan blue, while on the side facing the lamp the ring appears orange yellow.

* From the *American Journal of Science*, vol. xlvi., July, 1893.

† Trials with many kinds of paper showed that a white linen tracing paper was the best. It is not possible to describe this so that one may be sure of selecting a similar paper. It was obtained of Keuffel & Esser, Fulton Street, N. Y., and sold as "No. 202 Alba tracing paper."

Hues of the sides of the ring.—An idea of the hues and intensities of these colors, which cause astonishment even in those who are experimenters in chromatics, will be given by the description of the following experiments.

By means of a Bunsen photometer disk I adjusted the distance of the lamp from the screen so that I obtained as nearly as I could judge equal illumination of the sides of the screen. I then found that the blue was matched in a rotator by a disk having a sector of 60 parts of the circumference of Prussian

FIG. 2.

blue, with a sector of 10 parts of emerald green and of one of the many colored disks given me by Professor O. N. Rood and was marked, "Blue between cyan blue and the ultramarine of the physicist, but nearer the latter. Near F and on its more refrangible side. Made with Prussian blue." The blue on this disk appeared as saturated in hue as could be made by the pigment.

The match of the color of the side of the ring facing the lamp, L, in Fig. 3, was obtained by placing a

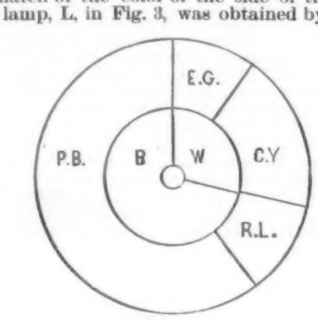


FIG. 3.

silvered mirror, M, so that the reflection of this side of the ring, S, was seen close to the rotator, R.

The color of the cardboard ring facing the lamp was matched by the rotation of a disk formed of 50 parts of chrome yellow, 30 parts of red lead (red orange) and 20 parts of white cardboard. Such appears to be the hue of the light of a petroleum flame when compared, in this manner, with the light of the sun.

The petroleum flame used in these experiments was that of a Belgian burner giving about 35 candles. The daylight was obtained from a window 85 cm. square; the lower half of which, when viewed from the screen, was occupied by the snow-clad surface of an opposite hill. The day was very clear, and the sky very slightly tinged with blue.

The colors of the sides of the ring of the screen are complementary.—I combined the Prussian blue, emerald green, chrome yellow and orange red on a disk on the rotator, and found that when the disk was formed of sectors having 60 parts of Prussian blue, 11 of emerald green, 19 of chrome yellow and 10 of red lead, I obtained a gray which was exactly matched by a central disk formed of 71 parts of dead ivory black and 29 of white cardboard. (See Fig. 2.) These measures gave the following equation:

$$\left\{\begin{array}{l}60 \text{ Prussian blue} \\ 11 \text{ Emerald green}\end{array}\right\} + \left\{\begin{array}{l}19 \text{ Chrome yellow} \\ 10 \text{ Red lead}\end{array}\right\} = \text{Gray}\left\{\begin{array}{l}71 \text{ Black} \\ 29 \text{ White}\end{array}\right\}$$

It is rather difficult to get the exact match on the rotating disk of the hues on the front and back of the cardboard ring of the screen, on account of the illumination of these surfaces. The rotator must be placed nearer the window than the screen, so that it is well illuminated.

The equation shows that the cyan blue of 60 parts of Prussian blue + 11 of emerald green is complementary to an orange yellow of 19 of chrome yellow + 10 of red lead. The hue of this orange of the lamp

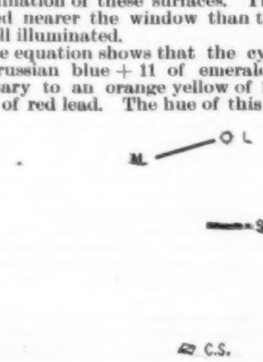


FIG. 4.

side of the ring, as given by the rotator, was 50 chrome yellow + 30 red lead + 20 white, which mixture is approximately in the proportion of 19 to 10. The correspondence of the two experiments is, I suppose, about as near as could be expected from the difficulty of matching the illuminated hues of the ring of the screen.

The small central disk on the rotator gave a gray of 71 parts of ivory black + 29 of white cardboard, which matched the gray given by 71 parts of cyan blue + 29 parts of orange. Calling the intensity of the orange 100, we have $100 \times 29 = 71$ I, which gives for I (the intensity of the cyan blue) only 40·8 per cent. of that of the orange.

The orange yellow of the side of the ring facing the lamp and of the side of the translucent paper facing the daylight is complementary to the cyan blue of the side of the ring facing the daylight and of the side of the translucent paper facing the lamp.

In Fig. 4, L is the lamp; S, the screen, which in this experiment is deprived of the border of translucent paper; W, the window; M, a silvered mirror which reflects the back of the screen to the eye, which looks through an achromatized double refracting calc spar prism at CS, and sees two images of the side of the screen reflected from the mirror and two images of the side of the screen facing the window. By suitably inclining and rotating the calc spar prism these images may be brought into the positions shown in Fig. 5, in which A represents one of the images of

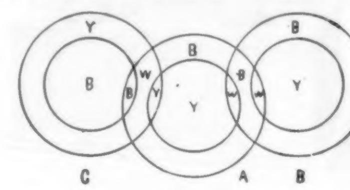


FIG. 5.

the side of the screen facing the window; B, the other image of the same; C is one of the images of the side of the screen facing the lamp and seen by reflection from the mirror.

The overlapping of these images, when the illumination is properly adjusted, gives the following results as shown by the letters in Fig. 5, where B stands for cyan blue, Y for orange yellow, and W for white. The translucent paper, Y, of B overlaps the ring of A and gives white, and the blue of the ring of B overlaps Y of the translucent paper of A and gives white. In the same manner the orange yellow of the cardboard ring of C overlaps the blue of the ring of A and gives white. Where the ring C overlaps the translucent paper of A there is a more intense orange, and when the blue of the translucent paper of C overlaps the blue of the ring of A we have a more intense blue. On bringing B of the translucent paper of C over Y of the translucent paper of A we have white.

Experiments on the complementary colors of gratings.—Out of thin cardboard, such as is used for thin visiting cards, I cut gratings with a dividing engine. (See Fig. 6.) The widths of the spaces cut out of

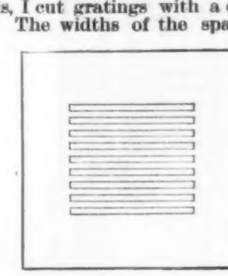


FIG. 6

these gratings exactly equaled the breadths of the cardboard left in the grating. Gratings were thus made having spaces of 1, 2, 3, 4 and 5 mm. The cardboard is rendered opaque by coating one side of it with ivory black in dilute shellac varnish. After it has dried the cardboard is well flattened before it is fastened to the surface of a piece of hardwood on the dividing engine. The cutting edge of the cutter for this work must have a very acute angle. I made one by grinding down a rod of Stubs' steel. Heating this to a dull cherry red and then forcing it into a large ball of beeswax gives the edge of the cutter the required temper, without the necessity of subsequently "letting it down." The blackened side of the gratings was covered with the "Alba tracing paper." The grating was mounted back of an opening in a black cardboard screen, so that only the white grating was exposed. Two other black screens, Wh and Y of Fig. 7, having openings of the same size as the grating and covered on the back

FIG. 7.

with the translucent paper, were placed on either side of the grating, G. In Fig. 7, L is the lamp. The window is on the other side of G. The screen, S, divides the apparatus so that the light of the window, W, reflected by the mirror, M, on to the screen,

Wh, cannot fall on G or on Y, which are only illuminated by the lamp, L.

The translucent paper of the grating, G, and of the screen, Y, appear orange yellow. The bands of white cardboard of the grating appear cyan blue. The translucent paper of the screen Wh is white.

Sit a little to one side of the grating so as not to intercept the light from the window, and look at the grating through the calc spar prism. Rotate it till the blue bands of the grating are superposed on the orange bands, when if the surface of the grating is equally spaced, the superposed surfaces appear white when compared with the white of the screen, Wh. Without the screen, Wh, the eye has no term of comparison and may take a yellowish white for white. The illumination of the screen, Wh, should be made equal that of the superposed images of the grating.

When this experiment is carefully made, with the proper illumination, the effect is suprising when, in favorable conditions, on rotating the prism you see the grating actually obliterated with no bands visible, but only a uniform white surface. The grating with spaces of 3 mm. gave the best results.

In experiments with the screen, Fig. 1, formed of the cardboard ring and the translucent disk, it is easy, by altering the relative intensities of the daylight and lamplight and by changing the distance of the lamp from the screen, to produce great changes in the saturation of the contrast colors. Indeed I have sometimes thus obtained, toward nightfall, a cyan blue so saturated in hue that little or no white was required in the disk of the rotator to match the color on the ring. In the same manner similar changes in color have been observed in the hue of the ring illuminated by the lamp.

On illuminating one side of the screen by daylight and the other by the white light of a Welsbach incandescent lamp, and then placing colored glasses or films of colored gelatine between the screen and the Welsbach lamp, effects of contrast are obtained which are so readily imagined by the physicist as to require no description; but they are worth viewing.

Increase of the purity and luminosity of the contrast colors by a rotating screen.—Make a disk of white cardboard of 27 cm. diameter, with eight sectors cut out of it, and cover it with translucent paper, so that the paper extends beyond the disk and makes a border 3 cm. wide. A circle of 8 cm. in diameter is left in the center of the disk and a ring of 1½ cm. on its border. This disk is shown in Fig. 8, but with only six sectors.

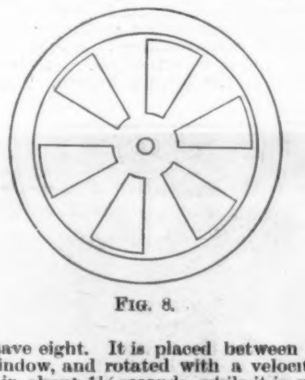


FIG. 8.

It should have eight. It is placed between the lamp and the window, and rotated with a velocity of one revolution in about 1½ seconds, while it is viewed on the side facing the window. The blue sectors thus take successively the places just before occupied by the sectors of orange yellow, and the effect is to heighten the contrast color in such a remarkable manner that the blue sectors by their more intense color appear separated from the rim and central circle and appear in a plane farther from the eye than the plane of the center and rim. On the side of the disk illuminated by the lamp the same effects are produced, only they appear more marked. A change will also be observed in the hue of the advancing and following edges of the sectors, on both sides of the disk; the advancing edges appearing more saturated in hue than the following edges.

A mode of observation by which contrast colors are intensified.—Simultaneous contrast colors are generally viewed by placing gray or tinted surfaces on colored grounds, or by the juxtaposition of colored surfaces. The effects thus produced are of such constant occurrence in the paintings of artists, and in colored fabrics, that their study is of great interest. The contrast colors thus produced have generally been studied by simply placing on a colored ground smaller gray or tinted surfaces and observing these with the unaided eye. This method has been improved by H. Meyer,* who viewed the gray on the colored ground when both were covered with white transparent paper.

The mode of observation I have devised for the study of contrast colors is as follows. A glass tube of 2·7 cm. in interior diameter and 10 cm. long is coated on the outside with black Japan varnish, so as to have reflection only from the interior surface of the tube. A ring of 3 cm. diameter with a central opening of 2 cm. is cut out of gray paper. The gray of this ring was matched on the rotator by a disk having 57 parts of ivory black and 43 parts of white Bristol board. This ring, placed on a surface of emerald green, appears of a rose color. If at the distance of distinct vision we look at the ring through the tube, we shall see the ring by direct vision inclosing a circle of green and surrounded by a ring of emerald green, and this inclosed by a rose-colored ring, produced by reflection of the gray ring from the interior of the tube, and surrounding this ring is another of emerald green, as shown in Fig. 9; in which R and R are the red rings and G, G, and G the circle and the two rings of emerald green.

The hue of the rose-colored rings as seen through the tube is much more intense than the hue of the ring viewed on the emerald ground with the unassisted eye. Experiments made with the aid of an achromatized calc spar prism, and by matching on a rotating disk the colors of the gray ring on an emerald green ground, showed that the intensity of the contrast color, as seen with the reflecting tube, is nearly double what it is when viewed by the eye alone. The color of the ring when viewed by the unassisted eye was matched on the rotator by a disk having 30 parts of Chinese vermilion + 7 of "Hoffman's violet R R R" + 34 parts of ivory black + 29 of white Bristol board. As seen through the reflecting tube, the match appeared to be given by 57 of Chinese vermilion + 15 of "Hoffman's violet R R R" + 28 of white Bristol board.

* Pogg. Ann., xcv., 170.

Another tube 4·5 cm. in diameter and 18 cm. long gave excellent results, with two reflected rings, and on nearer vision, with four reflected rings. A tube, suitable for these experiments, is selected by closing one of

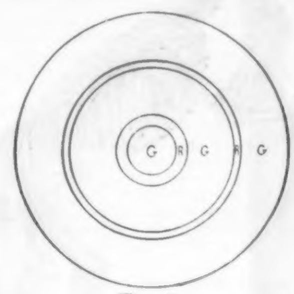


FIG. 9.

its ends by a disk of cardboard having a pin hole at its center. When the end with the pin hole faces the sky and we look through the other end, we see bright rings caused by the reflection of the light of the pin hole from the surface of the tube. If these rings are circular and concentric, the tube is of a circular section and its axis is a right line.

The value of this mode of observation is shown by the following experiments. Place the ring of gray paper, or a circle of gray paper, about 1½ cm. in diameter, on a surface painted with cobalt blue, not too saturated. The gray ring, or circle, appears of an orange tint. Place a similar gray ring, or circle, on a surface lightly washed with emerald green. It appears pinkish. The difference between the hues of the ring when viewed on the cobalt blue and on the emerald green, though decided, is not strongly marked; but if viewed through the reflecting tube, the ring on the cobalt blue appears of a rather intense orange and the ring on the emerald green appears of a rose color. When so viewed the difference in these hues is strongly marked.

Pieces of cardboard, painted with the following colors, were arranged in pairs. Orange yellow on the less refrangible side of D and orange yellow on the more refrangible side of D. Greenish yellow and yellowish green, both made with gamboge and Prussian blue. Purple of violet end of spectrum with added red, made with Hoffman's violet R R R, and violet between G and H, Young and Muller's fundamental color. Place a pair of the colors, as given above, side by side and on each put a gray ring, with a reflecting tube over each ring. When viewed by the unassisted eye the differences in hue are slight and difficult to define; but when viewed in rapid succession through the adjoining tubes the differences in hue are decided and may be readily matched in color with disks on the rotator.

(*To be continued.*)

LAUSSEDAT'S HEMIPERISCOPIC CAMERA LUCIDA.

THE application of Wollaston's camera lucida to the drawing of perspectives designed for figured plans is due to Captain Laussedat. We shall describe neither the classical apparatus nor its modifications, which are to be found in all treatises on physics. We shall merely say that the double reflection prism that forms the essential element of it has, for upright section, a quadrilateral, two sides of which make an angle of 90°, while the other sides make an angle with each other of 135° and with the two first sides angles of 67·5°. The edges of the prism being arranged horizontally, a luminous ray comprised in a plane at right angles with the edges, after entering through one of the rectangular faces, undergoes two total reflections upon the two 135° faces and makes its exit through the other rectangular face in taking a direction at right angles with that of the incident ray. The eye situated above the sharp angle of the face of exit then perceives a virtual image

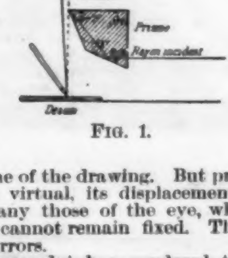


FIG. 1.

upon the plane of the drawing. But precisely because such image is virtual, its displacements at every instant accompany those of the eye, which, having no datum point, cannot remain fixed. There necessarily result grave errors.

Captain Laussedat has rendered the use of the camera lucida very practical by a few very happy modifications. He has, so to speak, fixed the position of the eye by shaping the upper horizontal face of the prism in the form of a spherical half cap whose center is upon the perpendicular to the horizontal face of the prism, passing through a point of its edge. The optical center and the point of view of the perspective are then fixed, and the drawing becomes very easy. The determination of the constants of the apparatus is equally so. The board and the edges of the prism having been arranged horizontally through the aid of a small spirit level, the point of view is projected upon the board with a plumb line, and we have the principal point. The horizon line passes through this point and is obtained by measuring a perpendicular to the image of any vertical whatever. The distance from the point of view to the drawing board is measured directly with a divided rule. We have thus upon the plane of the drawing all the elements capable of serving for the construction of the angles of the visual rays reduced to the horizon and of figured projections of the various points (Fig. 2).

When the objects are very distant, the images obtained upon the plane of the drawing by means of the camera lucida are too small, and, in order to enlarge them, Captain Laussedat in 1854 conceived the idea of adapting the camera lucida above described to the

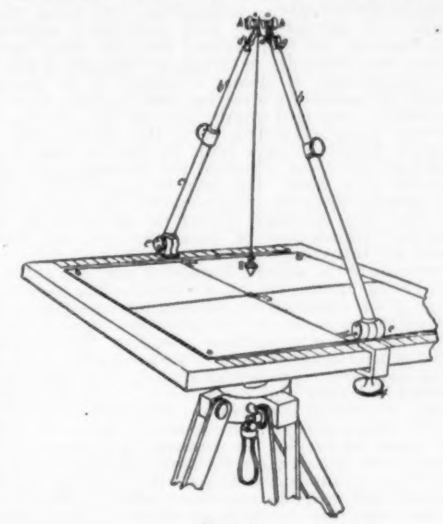


FIG. 2.

ocular of a magnifying telescope. This process was used during the war of 1870 for studying the approaches of the Germans at the siege of Paris. Captain Laussedat styled his apparatus a telemetrograph.—*Le Genie Civil.*

A PHOTO-TELEGRAPH.

By H. C. JOHNSON.

I HAVE taken considerable interest in the subject of the transmission of pictures or images by electricity, and in view of the article on this subject which appeared in your issue of Oct. 21, though not claiming to be an electrician, I have concluded to present the results of my own observations. It does not seem improbable that we shall some day be able to produce a device by means of which this much sought for result may be attained. Some one has stated, in substance, that the general principles involved will be the conversion of the picture to be transmitted into a series of electrical pulsations, and afterward causing these pulsations to act upon a receiver at the distant end of the line in such a manner as to reproduce the picture. It seems to me that the next point to be considered is whether it will be possible to transmit each illuminated point in the picture at (practically) the same instant over a single wire, or whether these points are to be transmitted successively, but with such great rapidity that the picture will appear to his eye as complete. I say this is the next point to be considered, for I have given considerable thought to the matter of transmitting each point independently, as, for instance, by separate wires, and while it may be possible even now to devise a construction by means of which the desired result could, theoretically, be realized, it is doubtful if a practical device will ever be made on this principle. The construction described in the article above referred to is based on this idea. Using the words of that writer, "the two instruments would, therefore, be connected by a large cable made up of many thousands of small insulated wires." Imagine, if you can, two telephone instruments connected by one thousand wires, even though they were formed into a cable. The transmission over a single wire of each point in the picture at the same instant would, undoubtedly, be the ideal method, but with our present knowledge it seems, perhaps, somewhat more visionary than the

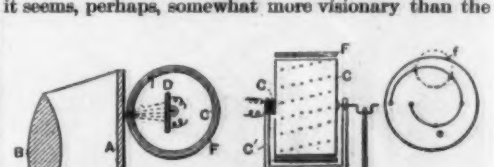


PHOTO-TELEGRAPH.

successive transmission of these points with such speed that the picture will appear as a complete thing. When the laws of physics in certain directions are better understood, however, the first method may not prove to be an impossibility. Some little time ago I worked out a device embodying the second method spoken of. While I fully recognize that there are many obstacles which it is difficult to overcome, and it is not claimed for a moment that the present construction does overcome any large proportion of these, yet the instrument has some features which may be of interest.

In the sketches A represents a plate of ground glass on which the picture to be transmitted is first received; in front of this plate is located a lens, B. The hollow, perforated cylinder, C, adapted to be revolved by any suitable means, is mounted in a vertically reciprocating frame, C′, and incloses a selenium cell, D, which is secured to the frame, C′, at C. The casing, F, which encircles the perforated cylinder, is provided at that portion nearest the plate, A, with a narrow horizontal slab, while the perforations or apertures are arranged

in oblique lines. As a result, only one perforation at a time can register with the slab in the casing, the object being to allow the rays of light from only one point on the plate, A, to reach the cell, D, at any particular instant. It will be seen that the revolution of the cylinder alone will provide for transmitting only one horizontal colored line in the picture, but as the frame carrying the cylinder is simultaneously reciprocated all of the points in the picture will, within a very short space of time, make their individual variation in the resistance of the selenium cell. I regard as especially important the construction whereby each illuminated point is allowed to throw its rays on the selenium cell for only an instant, the light being then entirely cut off until the next perforation registers with the slab. By this means I overcome what seems to be a grave difficulty in certain instruments in which the transmission of points is sought to be accomplished by means of a revolving disk having a series of apertures, *e*, arranged spirally near its edge (see Fig. 3), the disk being so located, say at the end of a tube, *f*, through which the rays from the picture pass, that light may reach the selenium cell through only one aperture at a time. The receiver has a similar disk, and both are revolved synchronously. It will be noted that the operation would be what might be termed a "transmission of lines," that is to say, there would be transmitted through each perforation a curved line of the picture, instead of only a point in a line. If the varying shades of an entire line were presented to the selenium cell without intermediate relief by total darkness, the cell would be less efficient, if not utterly useless for the purpose intended. The receiver of the present device consists of a plate similar to A, on which the picture is to be reproduced, and a perforated cylinder mounted and revolving in a reciprocating frame. Instead of the selenium cell, however, there is located within the cylinder a source of light and suitable means for varying the intensity of its rays to correspond with the varying strength of the electric current, which in turn depends upon the resistance of the selenium cell, and this resistance varies in proportion to the brightness of the point in the picture which may be influencing the cell at any particular moment. It will be understood that the cylinders must be operated synchronously and with sufficient rapidity to cause it to appear to the eye that all these rays of light of different degrees of intensity are thrown upon the plate at the same instant. It is probable that experiment alone would fully demonstrate how frequently it would be necessary to reproduce each particular point in the picture in order to accomplish this result. Should it be found that the resistance of the selenium cell could not be varied with sufficient rapidity, or that that portion of the receiver designed to throw rays of light of different colors or degrees of brilliancy could not be made to operate properly, the same principle could be extended almost indefinitely by the use of a number of cylinders, with their attachments, each transmitting only a small portion of the picture, although this would, of course, involve a few more connecting wires.—*Electrical World.*

MEGATHERIUM CUVIERI.

THE fossil shown in our engraving, which is from *La Ilustracion Española*, represents the gigantic fossil in the Museum of Natural Sciences at Madrid, and pertains to the Megatherium Cuvieri, which was found in

THE MEGATHERIUM CUVIERI.

quaternary ground on the banks of the river Luxan, about ninety miles from the capital of the Argentine Republic.

It was sent to the Museum in 1780 by the Viceroy, the Marquis of Loreto. This mammal, whose stature approaches that of the elephant, possesses some of the natural characteristics of the sloth, forming, in conjunction with other species of fossils, the family of the Megatheridos. From the form of its teeth it is observed that it lived upon vegetable food, and an examination of its skeleton shows that its normal position is not that of a quadruped, although its skeleton is so arranged in the Museum; but it is a biped, as the animal carries itself upon its hind legs and supports itself upon its tail, which is large and strong, much in the same manner as the kangaroo.

This more natural position of the animal is shown in our smaller engraving, which was taken from the gigantic skeleton cast of the Megatherium Cuvieri exhibited at the Philadelphia Exposition in 1876, by Professor Ward, of Rochester, N. Y. Concerning this creature, Professor Ward says: The first fossil remains of this animal were discovered in 1789, near Buenos Ayres, and were first transmitted to Madrid in Spain. The original bones, of which this specimen is a copy, were found in the same pampean deposit between the years 1831 and 1838, and belong partly to the Hunterian Museum and partly to the British Museum. To give to this singular quadruped its proper position in the animal kingdom was, for many years, a problem in comparative anatomy which the savans of Europe could not solve. Led astray by the huge carapace of the glyptodon found near it, the majority called it a mammoth armadillo. Cuvier, who gave it its generic title, thought that it combined the characters of the sloth, ant-eater, and armadillo. The merit of throwing a flood of light on the structure and nature of this the most remarkable of all fossil animals was reserved for the celebrated English geologist, Professor Owen, who conclusively proves that the megatherium was a ground sloth, feeding on the foliage of trees which it uprooted by its great strength.

The extreme length of the mounted skeleton is seventeen feet and nine inches; its height from the pedestal to the top of the spinous process of the first dorsal vertebra is seventeen feet. No other fossil so exceeds its modern representative as the lordly megatherium surpasses the pygmy remnant of the tardigrade race. One is tempted to join the Spanish naturalist who objected to the place assigned to the megatherium because "all the other edentates could dance in his carcass." But that there is the closest affinity between it and the diminutive arboreal sloth is now undeniable. The number of teeth, their deep insertion, equable breadth and thickness, deeply excavated base, inner structure and unlimited growth, and the absence of canines, are characters common to both. The part in which the megatherium least resembles the sloth is the tail; and, as a general rule, in those modifications of structure in which it differs from its living analogue it approximates to the ant-eater.

The head of the megatherium is remarkable for its relatively small size, for the extraordinary depth of the lower jaw, and for the great size of zygomatic process. The length of the skull is thirty inches—three inches less than the Asiatic elephant. The formation of the muzzle indicates the possession of a short proboscis.

The spinal column consists of seven cervical, sixteen dorsal, three lumbar, five sacral, and eighteen caudal vertebræ, and measures fifteen feet in length, or three feet more than the elephant's. The circumference of the skeleton at the eighth rib is eleven feet.

The megatherium differs strikingly from existing quadrupeds of corresponding bulk in the vast proportions of its anterior extremities. Its clavicle, fifteen inches long, is the longest known. The foreleg bespeaks enormous strength; with the foot it is seven feet four inches in length.

The hind legs appear more like columns for support than organs for locomotion, and, with the hind feet, are models of massive organic masonry. The heel bone alone has the extraordinary length of seventeen inches

THE MEGATHERIUM CUVIERI—FOSSIL IN THE MUSEUM OF NATURAL SCIENCES, MADRID.

and a circumference of twenty-eight inches. The monster walked like the ant eater, on the outside edge of its foot, on a marginal hoof-like callosity. The middle toe of the hind foot and fourth digit of the fore foot were armed with powerful claws. The magnitude of the tail fills the observer with wonder. When clothed with flesh it must have been more than six feet around at the greater end. With the hind legs it formed a tripod, upon which the animal rested when obtaining its food. It would be interesting to know something of the daily life of the animal whose colossal size was united to such strange anatomy. As the brain of the megatherium was less by nearly one-half than that of the elephant, we infer that he was a creature of fewer instincts. Nevertheless his contemporary quadrupeds must have acknowledged him as the head of the animal kingdom. To the tongue of a giraffe and the proboscis of a tapir there was added the power of rotating the bones of the forearm. These prehensile organs were suited to a leaf-feeder. That the animal was not carnivorous is settled by the structure of its molar teeth; it lacks incisors, therefore it was not a ruminant. But if the great animal fed on foliage, how did it obtain it? The elephant gathers its food with a long proboscis. The giraffe, standing on stilt-like forelegs and reaching out its attenuated neck, plucks the high branches with long flexible lips and muscular tongue. The megatherium could imitate neither. The forearms were plainly formed for grasping, and not climbing or digging; they were instruments of tremendous strength, evidence of which is furnished by the deep grooves and sharp ridges on the radius and ulna, the starting points of stout tendons and muscles. The moment we estimate this force, the colossal proportions of the hind extremities lose their anomaly, and harmonize with the front. The application of the forearms to the work of tearing down a tree would demand a corresponding fulcrum such as we find in the heavy pelvis, the ponderous tail, and the massive hind legs.

When stripping the trees it had prostrated, its position was probably a reclining one; and Prof. Agassiz ventured the opinion that this crouching attitude was constant to the animal, and that it crept along with the full length of the forearm resting upon the ground.

The pampas, where the remains of the great fossils have been chiefly found, are vast plains stretching from the mountains of Brazil to Terra del Fuego. Palms grow at one end, while snow covers the other almost the entire year. The soil is chiefly a dull, reddish, slightly indurated argillaceous earth, with here and there calcareous concretions; underneath are beds of stratified gravel and conglomerate. These deposits constitute the pampean formation, which varies in depth from twenty to one hundred feet. They were slowly formed at a time when the Atlantic reached far westward to the foot of the central mountain chain, down whose banks the rivers brought the detritus, and spread it beneath the waters in level layers at some distance from the shore. Carcasses of animals floated down upon the same streams, and, reaching the quiet waters, sank down in their muddy bed. The whole area has since been elevated, the estuary mud has been converted into wide and level plains, and the shores and submarine banks of a former sea now form low headlands along the present coast. It was in this recent formation—referable to the Pleistocene period, because most of its shells are still living in the ocean—that the megatherium was entombed. Its bones are almost exclusively found in the cliffs and steep banks of rivers—thus far, the rivers Salado and Luxan. The race was not exterminated by some great cataclysm, for the small bones, like the knee-cap of a contemporary mammal, were discovered by Darwin in the same deposit, all lying in their proper relative position. Like the aborigines of our own continent, like the dodo of Mauritius, the edentate giants perished one after another, in the lapse of infinite ages, by those changes of circumstances in the organic and inorganic world which are always in progress.

EARTHQUAKE AT KUSHAN, IN PERSIA.

A TELEGRAM from Teheran, the capital of Persia, gives further details of the recent disastrous earthquake in Kushan and the surrounding district. The first shock was felt on November 17, at half-past seven in the evening. It completely destroyed the town of Kushan and all the villages within a distance of seven miles, many of the inhabitants being buried beneath the ruins. The shocks continued until November 24. Up to that date, about a hundred and sixty distinct shocks were counted. On November 23 a great storm occurred. Heavy rains fell during the day and snow during the night, greatly increasing the sufferings of the inhabitants, who were camping out in tents. Supplies of food were being sent from the surrounding district and from Meshed, where slight shocks of earthquake have also been felt. According to the official reports the total population was 20,000, and of this number three-fifths were killed, while 50,000 animals perished.

The town of Kushan, in Khorassan, the northeastern territory of the Persian empire, is situated not very far south of the Russian Transcaspian frontier, being seventy-six miles south of Askabad, and nearly a hundred to the northwest of Meshed, visited by our special artist, Mr. William Simpson, on his journey to accompany the Afghan Boundary Commission. It is several hundred miles beyond the capital of Persia. The province of Kushan, a broad fertile valley, watered by the Atrek River, extending sixty miles below the Shah Jehan range of mountains, was an old Kurdish principality, and its governor is styled the Ilkhani. In the Hon. G. N. Curzon's excellent book of travel and statistical study we find some account of the town, which contained 12,000 people. The curious earthen mounds with doors, in the foreground of our view, are brick kilns.

The latest telegram, dated from Teheran, December 1, says: "Kushan is a heap of ruins; not a house remains standing. It is estimated that the loss of life has been two deaths to every house. There is some talk of building a new town to the eastward."—*The Illustrated London News.*

THE CITY OF KUSHAN, IN PERSIA, RECENTLY DESTROYED BY AN EARTHQUAKE.

THE JAPANESE EARTHQUAKE OF 1891.

By RALPH S. TARR.

THE Japanese are not unaccustomed to the quaking of the earth, but shocks as disastrous as that of October 28, 1891, are rather rare even in Japan. The last earthquake of marked violence, in any way comparable with this one, occurred in 1854, and since 1633 there have been but twelve severe shocks which may be ranked with that of last year. Scarcely a day, however, passes without some jarring of the earth which is appreciable to the senses, and those of us who live in a region comparatively free from earthquake shocks, such as the eastern United States, would be very much alarmed at shocks which are passed over with very little notice in Japan, and would have our confidence in the stability of nature very much disturbed. Centuries of experience have taught the Japanese that the earth is far from being the *terra firma* which we are accustomed to consider it.

Japan is doubly unfortunate in being the seat of the two main causes of earthquakes. It is, in the first place, a volcanic center, which always carries with it as a necessary adjunct recurrent jarrings of the earth, for each time the pent-up lava, struggling to reach the surface, overcomes some obstacle and rends asunder the deep-lying rocks, an earth jar is started which reaches the surface as an earthquake shock. Moreover, the rocks are still in a state of strain, for the country is geologically young and perhaps still growing, and this always means accompanying earthquakes, for when rocks are bent and folded or differentially elevated there comes now and then a time when the strain is relieved by a break or a slip in the rocks, and this sends a jar through the earth. New Zealand, Chile, Peru, and many other parts of the earth are in this state, and here earthquake shocks are liable to be both numerous and violent. These two theories do not exhaust the possible causes of earthquakes, but from them the great majority of such shocks result, and while we cannot exclude the other causes from Japan, we certainly can say with safety that nearly all are caused by the one or the other of these accidents.

So liable are the Japanese to be rudely shaken that the investigation of earthquakes has in that country become one of the most earnestly studied sciences, and the Seismological Society of Japan has become famous the world over. There is no part of the earth where every form of earthquake is as carefully studied as there, for it is the hope of the nation that as a result of this study it may be found possible, in a measure at least, to predict the approach of severe shocks. The chief damage to life in an earthquake comes from the falling of houses, and if the people can be warned in time to seek safety without, it will be a great boon to the nation. Probably in no civilized country in the world is the danger from falling timbers reduced so nearly to a minimum as in Japan, for the centuries of disastrous experience with earthquakes have taught these people to construct their dwellings with special reference to the possibility of destruction by this means. A shock which in Japan kills ten thousand people would in our own country, if in an equally populous region, destroy fully ten times that number.

The disaster of 1891 has been recently reported upon by the scientific societies, but before this we knew from the native newspaper reports enough about the shock to state the facts of general interest. It is a curious fact that the Japanese expected some such calamity to befall the country on or about His Majesty the Emperor's birthday, which occurred only seven days after the shock. There is no obvious reason for this superstition, since violent earthquakes in Japan do not recur at regular intervals; but the coincidence will go far toward fixing superstition in the minds of the common people, who are already inclined toward it.

The region visited by this earthquake is a well settled one, and one into which modern improvements had been quite extensively introduced. Mino Province, about two hundred and twenty-five miles from the capital, was chiefly affected; but the shock was felt in Yokohama and Tokyo, there being in the latter city some nineteen shocks in all, each sufficiently sharp to cause alarm, but none having force enough to do any particular damage. About four thousand square miles were visited with almost instant devastation, eight thousand people were killed by the falling of buildings or by the fire which followed, ten thousand were wounded more or less severely, and ninety thousand houses were destroyed. On the first day there were seven hundred minor shocks, and in a month seventeen hundred were recorded.

The population of Aichi and Gifu-kens was about two million four hundred thousand, and of these seven thousand five hundred were killed and nine thousand four hundred and fifty wounded. That is to say,

about three in every thousand were killed and four wounded. The death rate was thus not very great, though the aggregate was large; but this small death rate was the result chiefly of the character of the dwellings, and had they been made of brick of several stories, instead of one story wooden dwellings, the destruction would have been much greater. As it was, full half a million people were rendered homeless.

Gifu and Aichi, where the chief damage was done, were the centers of an important porcelain industry, and were reached by railroads and roads which crossed the streams by substantial bridges. We have, therefore, an opportunity to observe the effects of a severe earthquake shock in a region having many of the improvements of modern civilization, and some of the effects are most marked and peculiar. The foreign made buildings, with their tall chimneys, were in many places completely wrecked; but, fortunately, the shock occurred at a time when they were not occupied, and the destruction of life was less marked than it might have been later in the day.

At about half-past six in the morning of the 28th of October a rumbling noise was heard, followed almost immediately by a violent shock. The first shock, which caused the fields to rise and fall like waves and gave to almost every one a sensation resembling seasickness, brought nearly half the houses in Gifu to the ground, and many of those which still stood yielded at the second or third shock. At eight o'clock a fire broke out in four places simultaneously, and before it was subdued, the next day at noon, nearly seventy per cent. of the town was in ruins. The people were with difficulty enlisted in the fight against the flames, for more than half of them were broken-hearted over the loss of their home or were engaged in the sorrowful task of searching for lost loved ones or in assisting the wounded. People without home or shelter were forced to live in the open air, and the whole town was a camp and a hospital combined. Many who escaped unharmed were made ill from exposure, and in this indirect way died from the effect of the earthquake.

There are many interesting and pathetic stories told of the effects of and phenomena attending this shock. At Nagaya about forty Christians were assembled at an early prayer meeting in the large foreign building of the Methodist Protestant school. In the midst of the meeting there suddenly came the sound of distant rumbling, and almost immediately a decided quaking began. For an instant no one moved, expecting it to be over soon, but the rumbling increased to an awful roar and the building began to creak and rock, and as the terrified crowd was half out a flying mass of brick and tiles came tumbling down on them. The writer of the account from which the above was taken was one of the party, and he says: "The scene was truly awful to any one not accustomed to a field of battle, to see all those dead and wounded lying motionless or gurgling bloody fountains from every aperture. We were busy enough with this scene, but the whole city was in an uproar. Wild shrieks, shouts, and innumerable noises filled the air, while every few moments came the terrible thunder from the angry earth. Running through the city to call doctors, I found that none could be obtained for any price; but many streets blocked with fallen houses, and others choked with people rushing to and fro or standing dazed and gazing at the ruins."

There are many accounts like this, and every traveler through the region and every correspondent had some tale of disaster, some heartrending story to relate. There were children who had lost their parents and knew of no living relatives, mothers who had lost their children, and husb nds whose wives lay beneath the trembling ruins, all rushing about in indescribable anguish or sitting about stunned and stupefied by the terrible calamity which they had not yet fully realized. The scene must have been an awful one!

Not only were houses thrown down, but much damage was done to the earth itself. The region most severely visited was, as is often the case in an earthquake shock, the alluvial lands. The rice fields were tossed up and down and rent asunder, and all the roads in the most rudely shaken sections were rendered impassable except to pedestrians, by the crevices which crossed them. This cracking open of the earth is a common accompaniment of severe earthquakes, and in this shock cracks were found having a depth of fifteen to twenty feet and a width at the top often fully as great. In the great Calabrian earthquake, as well as in others, these cracks opened and closed, engulfing and entombing people; but in the Japanese shock no cases of this sort were reported.

As in all earthquake shocks, there were some peculiarities in the distribution of violence. In some cases parts of one village were destroyed, while other parts were only slightly damaged, and in neighboring villages the effects of the shocks were often widely different. No cause can now be assigned to this; but undoubtedly when the official report is made it will be found that these variations resulted from some peculiarity of the underlying rocks or soil. In some instances, however, these apparent differences in distribution of violence were due to the character of the dwellings. This was noticeably the case in a little hamlet of some twelve or fourteen houses on the bank of the Nagaragama. Only one of these houses had fallen, although from other evidences it seemed certain that the shock had been as severe here as elsewhere. The reason for this immunity seems to have been that the houses had slate roofs with eaves only slightly projecting instead of the usual tile or thatch roofs with projecting eaves. The houses were thus light and compact and could oscillate to a third of a right angle before falling over.

So violent was the earthquake that it is stated that in one place a grove of trees was bodily thrown to one side and remained permanently in their new position. As the earth opened water spouted out; the water in the wells became turbid and remained unfit to drink for several days, and the river Kiso changed its course, some parts becoming shallow or dry, and parts of the bank becoming converted into river channels. Much damage was done to the railroads and the telegraph service, the poles being thrown down and the wires broken. In one place the railroad track was thrown into a series of serpentine waves, as shown in one of the photographs. Especially were the railroad bridges damaged. Massive piers of masonry were cracked and destroyed, iron piers were overthrown or caused to sink into the river, allowing the bridge to settle in the middle, and upon the banks the earth was very commonly depressed beneath the track, leaving it suspended in mid-air.

A correspondent of the Hiogo *News* writes: "Passing clear of the bridge, an unprecedented view met our gaze. We could see as far as the Nagarawa. It was like a tobogganing road, with its devious undulations, twisted far, far out of the original direction of the line. Between these two bridges the earth subsided more than we had yet witnessed. Outside the bridge, the sleepers and rails were suspended in mid-air about eighteen or twenty feet, and the vibration, as we picked our way over them, was rendered the more unpleasant by a distinct shock of earthquake, whose approach was heralded by the low booming sound, as of distant thunder. Passing on, we crossed a small run spanned by a three-arched iron bridge. It had staggered at the impetus of the shock, the massive stonework pillars had fallen back and split, and it lay resting on the outer edge of the support almost turned completely over, only the rails preventing its being precipitated into the quivering river bed."

Within a very short time a scientific account of this earthquake has been published and its cause satisfactorily explained. It has been found, upon a study of the region visited by the disaster, that an actual break in the strata occurred, and that they slipped past one another or were faulted. This fault appeared at the surface in the form of a crack, on one side of which the ground was elevated several feet for a distance of many miles. The severe shock occurred at the time when the strata broke asunder; and the many minor jars which followed were caused by the slight slippings along the line of faulting.

It is very rare that the cause of an earthquake appears at the surface; but geologists who have studied mountain regions are familiar with the fact that in past geological times immense faults have been formed, sometimes with a throw of hundreds and even thousands of feet. In the case of an uplift of a few, perhaps a score of feet, a disastrous earthquake was caused. What, then, happened during the formation of so great a fault as some of those just mentioned? Perhaps much more violent earthquakes, but more probably many shocks. It does not seem probable that these faults were suddenly formed; but they were the result of successive movements. As the earth contracts, the strain becomes too great and the rocks break. They then rest for awhile, and again move along the same line, until ultimately they have moved hundreds of feet. This Japanese fault line will probably furnish a slipping plane again, and perhaps it has already done so in the past, for in a few scores of years all signs of the fault at the surface will be erased.

Many details might be added, but it seems hardly desirable to attempt any more than this general statement. The shock is but one of many which Japan has experienced, and was not as destructive as some that have occurred in other parts of the world, or even in Japan itself. It is, however, the only really violent shock which has occurred in a civilized country into which modern improvements have been partially introduced; and, although these improvements have by no means rendered the country under consideration in all respects comparable with our own, it still furnishes us with a basis for an estimate of the effect which such a shock would produce in our own country.

All European or American structures in the region visited by the calamity were badly damaged or completely ruined. While many of the native houses and castles stood through the successive shocks, the pottery and tile works, the high chimneys, the cotton mills, and other structures not Japanese in style were thrown down. What, then, would be the effect in New York City, or Boston, or Chicago if a shock even half as violent as this one should visit one of these cities? The heavy, projecting roofs, the tremendously high blocks and towers, and the poorly constructed houses would all fall with terrible destruction of life. This may never come to pass; but already in her short history this country has been visited by three distinctive earthquakes, one near Boston, one in the Mississippi valley, and one at Charleston, South Carolina, the last being, perhaps, the least violent of the three. It is probable that neither of these, unless the second be excepted, was as violent as that of Japan in 1891; but each shock was sufficiently severe to do much damage to-day in any of our large cities. Fortunately we do not dwell in a region where it can be said that such a calamity *will* befall us; but, unfortunately, we must confess that it *may* come.

[FROM THE GARDENERS' MAGAZINE.]

SINGLE CHRYSANTHEMUMS.

IMPROVED systems of cultivation, coupled with the labors of enthusiastic raisers of new varieties, have for years past been steadily raising the standard of size in the Japanese chrysanthemum, until we have now flowers so magnificent as to compel a tribute of admiration even from the most ignorant observer. This has, however, proved a loss in one way, as these grand blooms are not by any means the most suitable for general floral decoration, and I heard a gentle complaint from a lady a few weeks ago, that she had nothing to cut from, though her gardener's display of chrysanthemums had been the admiration of the countryside. The illustration of single chrysanthemums and my remarks thereon will perform a genuine public service if they attract attention to this charming section, and especially to its suitability for cutting purposes. The flowers are not only beautiful individually, but form the most delightful and artistic arrangements in almost any way in which cut flowers can be used, and the blooms are so graceful in themselves that it is almost impossible to arrange them so that they do not produce a good effect. We have also an ample range of color, embracing all the principal shades, so that there is no lack in this respect. Another point of great importance to amateurs and people of small means is that the system of culture is of the simplest, neither requiring deep study to acquire nor large expense to put into practice. All that is necessary is to make neat bushy plants by pinching two or three times in the earlier stages, with ordinary care in watering, etc. In conclusion, I would strongly advise every lover of flowers to grow a few of these charming plants, and would also remark to the gardener who is already a chrysanthemum enthusiast that a few good bushes of the single varieties will provide a profusion of cut flowers through the season, and perhaps save him the annoyance of sacrificing show blooms to a purpose for which they are scarcely suitable.

CHAS. E. PEARSON.

Chilwell Nurseries, Notts.

VASE OF SINGLE CHRYSANTHEMUMS.

THE HISTORY OF FOOTGEAR.

THE history of footgear dates back almost as far as that of human civilization. It is true that we find that, in ancient Egypt, the laborer, the soldier, and the man of the people went barefooted, but sandals formed part of the costume of the man of rank. They could not be worn, however, in the house of the king or in his presence. The Egyptian sandal was held in place by means of a strap that passed over the instep and was attached to another strap that likewise passed over the instep, but in a longitudinal direction. This latter was fixed, between the great and second toe, to the point of the sandal, which was curved upward (Figs. 1 and 2). The straps were often provided with ornaments. In addition to sandals, of elegant form, the Egyptian ladies wore gold anklets enameled in various colors. The legend as to the way in which Nitokris reached the throne of Egypt through the possession of the smallest and prettiest foot in the kingdom recalls our story of Cinderella. The Assyrians employed sandals with heel pieces and which were likewise provided with straps (Fig. 3). They wore, too, a long foot covering, recalling some of those of later times (Fig. 4). The Persians were fond of coloring their footgear saffron-yellow, and ornamenting it at the top. Among the Greeks, we find in addition to the ordinary sandals observed upon almost all the statues (Fig. 5), a half shoe with heel piece and tie (Fig. 6), and even a laced shoe, worn principally by women (Fig. 7). In the Tanagra clay figures this latter is colored red, with the sole bordered with yellow.

The foot coverings of the Romans (Fig. 8) were distinguished by the care employed in their manufacture and by their strength. Those of the soldiers were very heavy and provided with nails. The system of straps was arranged as among the Greeks. Shoes covering the ankle (Fig. 9) formed part of the costume of the senators. In the time of the emperors, red was employed by preference as the color for footgear.

Among the Byzantines, the world of fashion substituted leather or silk shoes for sandals. To these, the rich added silk stockings that reached the knees. Shoes embroidered with gold and ornamented with pearls were worn by persons of high rank.

The Germans, before the great emigrations of the bronze age, knew only the foot covering made of a single piece of leather and fixed to the foot by means of a strap passing through the edges (Fig. 10). When they employed skins for this purpose they turned the hairy side outward. In the third and fourth centuries, the leg was surrounded with bands that were kept in place by the straps of the foot covering (Fig. 11). This form of covering remained in use until the tenth century. It is to this epoch that belongs the German shoe (Fig. 12). Figs. 13 to 16 represent the shoes of the Carlovingian epoch, which were ornamented with taste. Fig. 17 shows a Norman shoe of the eleventh century.

The foot coverings of the flourishing age of chivalry had exactly the form of the foot and terminated in front in a small point. The material employed was fine leather, silk and even fabrics of gold, especially for the shoes of ladies. They were ornamented with pearls and provided with laces. Black, white, yellow and red were the colors preferred (Figs. 18 to 22). Although from the standpoint of taste we have no fault to find with the small pointed toe just mentioned, the same is not the case as regards those horrible shoes "à la poulaine" of the fourteenth and fifteenth centuries, which fashion wished to be ever longer and longer (Fig. 23). The points of these shoes were made of stiff material, or else were soft or were stuffed to keep them straight. They were sometimes provided with rattles. Sometimes, too, they were fixed to the knee or the girdle by a small chain. James I., king of Scotland, adopted the latter fashion. In order to prevent the points from being exposed to the mud of the bad streets of this epoch, shoe bottoms were invented that were held by straps. They were of wood covered with metal and sometimes also of leather, and ornamented with chased work (Fig. 24). These inconvenient points were a sign of nobility, and those who wore them did not wish to go without them even in time of war. At the battle of Sempach (1386), these points were not yet of iron. In case of necessity it was consequently possible to easily rid one's self of them; but, during the second half of the fifteenth century, the shoe was wholly of iron. Fig. 25 shows the foot of a Burgundian knight of the time of Charles the Bold. It was not till the beginning of 1480 that this fashion began gradually to wane. Since 1212 secular and ecclesiastical assemblies had tried in vain to check it. The little success that their tentatives met with is explained by the fact that the degree of nobility was measured, so to speak, by the length of the point. Thus, in the time of Philip the Handsome, the barons wore shoes two feet in length.—*La Science en Famille.*

FIGS. 1 AND 2.—Egyptian Sandals. FIGS. 3 AND 4.—Assyrian Sandals. FIG. 5.—Greek Sandal. FIG. 6.—Greek Shoe. FIG. 7.—Laced Shoe of Greek Lady. FIG. 8.—Roman Shoe. FIG. 9.—Shoe of Roman Senator. FIGS. 10, 11, AND 12.—German Shoes of the Bronze Age. FIGS. 13 TO 16.—Shoes of the Carlovingian Epoch. FIG. 17.—Norman Shoe. FIGS. 18 TO 22.—Footgear of the Age of Chivalry. FIG. 23.—Shoe "à la Poulaine." FIG. 24.—Same with wooden support. FIG. 25.—Iron Shoe of Burgundian Knight.

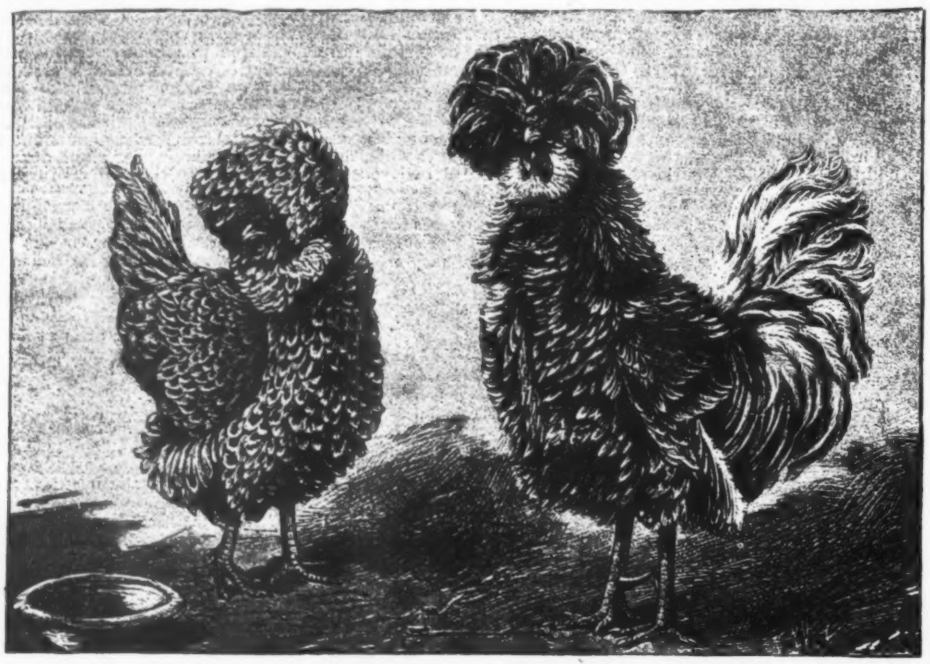
MSS. OF THE NEW TESTAMENT.

No fewer than 1,760 ancient manuscript copies of the New Testament in whole or in part exist, their abundance markedly contrasting with the small number which have come down to our own day of the classical writers. As no miracle has been wrought to preserve copyists from error, the last century added up 30,000 various readings in the New Testament manuscripts; and the present one has increased the number to 150,000. Some interesting particulars are given in the "Sunday School Teacher's Bible Manual" for December. Only the merest fraction of them are of any consequence; and their number, and the fact that they were made originally in different parts of the world and from a variety of manuscripts, enable Biblical students to detect and eliminate the errors and approximate to the original text more closely than if the various "readings" were fewer. This tedious but necessary work has been carried out with untiring energy. The New Testament manuscripts fall into two divisions: "Uncials," written in Greek capitals, with no distinction at all between the different words, and very little even between the different lines; and "Cursives," in small Greek letters, and with divisions of words and lines. Professor Roberts dates the change between the two kinds of Greek writing about the tenth century. Only five manuscripts of the New Testament approaching to completeness are more ancient than this dividing date. The first, numbered by Biblical critics A, is the Alexandrian manuscript. Though brought to this country by Cyril Lucar, patriarch of Constantinople, as a present to Charles I., it is believed that it was written, not in that capital, but in Alexandria; whence its title. It is now dated in the fifth century, A.D. The second (known as B) is the Vatican manuscript. It has been in the Vatican library from 1475 or an earlier period, but not till A.D. 1859 was an edition of it published, and that one, by Cardinal Mai, when issued, was uncritical and of little value. But in 1868 a facsimile of it came forth, so that now it is fully accessible to scholars. The Vatican manuscript dates from the middle of the fourth century, if not even from an earlier period. The third (C), or the Ephraem manuscript, was so called because it was written over the writings of Ephraem, a Syrian theological author—a practice very common in the days when writing materials were scarce and dear. It is believed that it belongs to the fifth century, and perhaps a slightly earlier period of it than the manuscript A. The fourth (D), or the manuscript of Beza, was so called because it belonged to the reformer Beza, who found it in the monastery of St. Irenæus, at Lyons, in A.D. 1562. It is imperfect, and is dated in the sixth century. The fifth (called Alpha) is the Sinaitic manuscript obtained in 1844 by Professor Tischendorf from the monks belonging to the convent of St. Catherine, on Mount Sinai. It contains the whole New Testament. It is believed that it was made in the fourth century, and its value to the Biblical critic is very great. Any other "uncial" manuscripts that exist are only fragmentary. The cursive manuscripts, though numerous, are of too late a date to stand on the same level for critical purposes as the "uncials." It is possible indirectly to gain access in whole or in part to the readings in manuscripts which have perished. There were early versions of the New Testament in different languages, such as the Syriac, etc. In many cases these were made from manuscripts not now existing, but the translation shows what the original must have been. Christians of the early ages, like those now living, were accustomed formally to quote or informally to allude to particular Scripture passages. When there is reason to believe that it was done with precision, it is easy to ascertain from their writings what the original reading was in the manuscript of the New Testament in their possession.—*Public Opinion.*

THE BREEDS OF FOWLS.

THERE has just appeared at the book house of Emile Deyrolle a work on the "Breeds of Fowls," by Mr. La Perre de Roo, giving a complete history and description of all the breeds of fowls known up to the present time, and they are numerous.

The domestication of the barnyard fowl dates back to remote antiquity. Darwin, says the author, thinks that he is able to fix the time of the introduction of it into Europe in the sixth century before Christ. Formerly there was but a single species of wild cock known, but now we know four very distinct and characteristic species, viz., the Bankiva cock (*Gallus Bankiva* or *ferruginea*), the Lafayette or Stanley cock (*G. Lafayettii* or *Stanleyi*), the forked cock (*G. furcatus* or *varius*) and the Sonnerat cock (*G. Sonneratii*). It is especially in the vast forests and the mountains of India and other countries of Asia that we find the various species of wild fowl in large numbers. They are met with also in the wooded portions of the mountains of Java, Ceylon, etc.



COCK AND HEN OF THE FRIZZLED BREED OF CHILE.

To return to the work above mentioned, let us say that it contains a description of all the breeds known, their history, particular study of the male and female, their habits, characteristics, etc. All the varieties, moreover, are studied and discussed. The work is illustrated with 121 figures in the text and 32 plates, both in black and colors, giving the principal types. We give herewith two specimens of these engravings, representing the cock and hen of the frizzled breed of Chile, the cock and hen of the breed known as *sabot*, and the cock and hen of the breed of Nangasaki, variety cuckoo. We are happy to make the appearance of this very complete work on the breeds of fowls known.—*Le Naturaliste.*

VEDALIA CARDINALIS—A TRIUMPH OF SCIENTIFIC METHOD.

SOME three or four years ago California orange culturists were almost in despair at the ravages in their orange groves of an insect known variously as the Fluted Scale, the White Scale or the Cottony Cushion Scale (*Icerya Purchasi*). For a time it looked as if orange culture would have to be abandoned in California, but just in the nick of time Prof. Riley, Government Entomologist, came to the rescue. He had, after careful investigation, definitely ascertained that the scale in question was a native of Australia, and that it was not practically injurious there. Here was the clew, and it was skillfully followed up. Long correspondence with Australian entomologists, and the dispatch of a carefully instructed agent to that country, resulted in the discovery of the parasite now so well known as *Vedalia cardinalis*, which keeps the Cottony Cushion Scale in subjection in its native home. When the scale was inadvertently brought over to California upon Australian oranges, *Vedalia* had been left behind, with the result that its host, the scale, had multiplied without restraint, as commonly happens when an insect is imported without its natural checks. Forthwith a large shipment of living Vedalias was made from Australia to California, and the surprising result is known to everybody. Within a few months the scale was obliterated, orange culture was again on its feet, and *Vedalia* had become a household word in California.

The experiment was successfully repeated in the Hawaiian Islands, where also the scale threatened to extinguish orange raising, and last fall a special commissioner from the Cape of Good Hope arrived in the United States, with the purpose of securing a supply of Vedalias for use in his country, where the scale was menacing orange culture. He was given every assistance possible, both at Washington and in California, and went home with a good stock of the insects. One package was kept upon ice during the voyage (the method adopted in the original importation into California) and a second was left open, that the insects might be fed *en route.*

The special commissioner alluded to, Mr. Thos. A. J. Louw, has recently reported to the Department of Agriculture the entire success of this latest colonization of *Vedalia*, the insects having reached the Cape alive and well, and been distributed to various infested localities, and there is every reason to believe that they will make as rapid and effectual a clearance of the scale in South Africa as they have in California and Hawaii. In closing his letter to Assistant Secretary Willets, Mr. Louw says:

"While thanking you again for the kindness displayed toward me, may I request you also to convey to Prof. C. V. Riley my extreme obligations for the service rendered by him to me, and which I assure him will ever be appreciated by me."

Vedalia is rather a pleasing name, and it is not surprising that there should be as a substantial commemoration of this entomological romance a Cathryn Vedalia Riley, the youngest of five girls, who form part of a happy family at the well-known entomologist's home at Sunbury, in Washington.—*Meehans' Monthly.*

COCK AND HEN OF THE BREED CALLED SABOT.

COCK AND HEN OF THE NANGASAKI BREED; VARIETY COUCOU.

ANTARCTIC SEALS.

By WILLIAM S. BRUCE, Naturalist to the Antarctic Expedition, 1892–93.

AFTER a period of dormancy extending over more than half a century, the Antarctic is again being opened up to scientific investigation and to commerce. Scotland and Norway sent out five vessels last year, and Norway is again to the fore this year; New Zealand also is said to be eager to join the chase. It seems also likely that work of a more purely scientific nature will be undertaken in the Antarctic during the coming year. Some readers may, therefore, be interested to hear something about the southern seals, which differ very considerably from those of the north.

In the Antarctic only two of the great families of seals are represented; they are the sea lions and sea bears, or eared seals (*Otariidæ*), and the more specialized true seals (*Phocidæ*); the intermediate family of walruses (*Trichechidæ*) being entirely absent. In recognizing nine different species of *Otariidæ*, Mr. J. A. Allen divides the family into five species of sea lions and four species of sea bears, and three of these five sea lions and three of the four sea bears belong to southern seas. The true seals he divides into sixteen species, and five out of these sixteen species of true seals belong to southern seas. It is from the sea bears of the *Otariidæ* family that ladies' sealskin jackets are made; the under skin, to which the long, rigid hairs are attached, is shaved off, and the long hairs fall out, leaving the upper skin with the soft under fur alone. The Falkland Islands fur seal (*Arctocephalus falklandicus*) is noted, however, for the evenness, shortness and elasticity of the fur. The fur is soft enough to wear as a rich fur without the removal of the longer hairs, which are always removed in the other fur seals. The skins of all other seals, whether sea lions or true seals, are used for making leather. The tens of thousands of seals that are slaughtered annually off Newfoundland and Greenland supply us with patent leather, and similarly the twenty to thirty thousand seals' hides that the Dundee whalers brought home from the Antarctic last spring will eventually be used for the same purpose. Crocodile leather, which we see in such vast quantities nowadays, is also said to be largely made from seals' skins. Besides skins, seals provide a great quantity of oil. During the recent trip to the south, the Dundee vessels secured from seven hundred to one thousand tons of seal oil; this is largely used in the jute manufactory for moistening the fibers, and this fact possibly accounts for Dundee not only being "Juteopolis," but also practically our only remaining sealing and whaling port. But now mineral oils, which are so cheap, are taking the place of animal oils in the jute factory, as they have in other branches of industry, and the masters and owners of sealers and whalers are beginning to think it hardly worth while fishing seals and whales for oil alone.

Concerning the sea bears, or fur seals, and the sea lions, or hair seals, of the Antarctic very little is known. The former have an abundant soft, silky under fur, are black when young, and ultimately yellowish or whitish-gray color; and the latter, the sea lions, have no under fur, but only coarse, hard, stiff hair; they are yellowish or reddish-brown, dark when young, but become lighter as age advances. The groups generally live apart, but have the same geographical distribution. They are gregarious, polygamous, and the males are from three to five times as large as the females. They differ very markedly from true seals in having the power to turn their hind limbs forward, and thus use them for locomotion on land; the presence of a small external ear is another characteristic. Of the Alaskan seal herd, Mr. H. W. Elliott gives the following graphic description, which may be extended to the southern herds: "The fighting between the old males for the cows is mostly—or, rather, entirely—done with the mouth. The opponents seize one another with their teeth, and then, clenching their jaws, nothing but the sheer strength of the one, and the other tugging to escape, can shake them loose, and that effort invariably leaves an ugly wound, the sharp canines tearing out deep gutters in the skin and furrows in the blubber, or shredding the flippers into ribbon strips.

"The bulls generally approach each other with comically averted heads, just as though they were ashamed of the rumpus which they are determined to precipitate. When they get near enough to reach one another, they enter upon the repetition of many feints or passes before either the one or the other takes the initiative by gripping. The heads are darted out and back as quick as a flash; their hoarse roaring and shrill piping whistle never cease, while their fat bodies writhe and swell with exertion and rage; furious lights gleam in their eyes; their hair flies off into the air, and their blood streams down. All this combined makes a picture so fierce and so strange that, from its unexpected position and its novelty, this is one of the most extraordinary brutal contests man can witness."

Mr. J. A. Allen has done much to simplify the classification, but the utmost confusion exists in most of the attempts made to classify them. Many attempt to divide them into a great many genera, but Mr. Beddard considers that if "the genus be split up at all it should be divided into *Otaria*, containing only the Patagonian sea lion (with its various synonyms) and *Arctocephalus*, comprising all the other species." The latter have narrower and more pointed noses and longer ears, besides other anatomical differences. The most notable is the Patagonian sea lion (*Otaria jubata*), which is represented by a living specimen in the gardens of the Zoological Society. Besides inhabiting Patagonia and the coasts of South America, this remarkable animal is also found in the Falklands. As is well known to frequenters of the Zoological Gardens, this animal in captivity becomes remarkably tame,

and even shows great affection to those who attend to its wants. The Cape sea lion (*Otaria pusilla*) inhabits the islands south of Africa. A living representative of this species is also to be seen at the society's gardens, its pond being close to that of the public favorite; it is smaller than the Patagonian sea lion, and is less familiar to the public. The Australian seas have also a representative. Strictly speaking, perhaps one should exclude most of the *Otariidæ* from Antarctic fauna, but in a wide sense most of the localities above mentioned are spoken of as being within the sphere of the Antarctic regions. In places such as South Georgia, the South Shetlands, and the island of Mas-a-fuero, near Juan Fernandez, and other localities where these animals abounded, they now no longer exist, on account of the excessively greedy ravages of man.

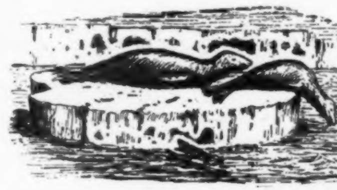
Formerly there was an extensive fur seal trade in South America and the Falkland Islands, in Australia, and in South Africa; but now there are so few seals in these localities that they are not worth hunting. In the Falkland Islands, however, it is pleasing to hear that the fur seals are now increasing in numbers, the most rigid protection being enforced; but with no telegraphic communication, and with no railways in the islands, poachers are said often to be able to secure a considerable amount of booty and make off before the authorities are able to enforce the law. In islands lying within New Zealand or Tasmanian waters a close season has also recently been proclaimed.

The true seals are represented by five species and two genera (*Allen*); they are the white Antarctic seal (*Stenorhyncus carcinophaga*), sometimes called the "crab eater seal" (for what reason it is difficult to say); the sea leopard seal (*Stenorhyncus leptonyx*); Weddell's false sea leopard seal (*Stenorhyncus Weddellii*); Ross' large eyed seal (*Stenorhyncus Rossii*); and, lastly, the monster seal known as the "sea elephant seal" (*Cystophora elephantina*). Skulls, and in some cases complete skeletons, of most of these seals are exhibited in the British Museum, South Kensington, and the College of Surgeons Museum, as well as in some of the provincial museums; one or two stuffed specimens also occur.

Of these five species the first two, the white Antarctic seal and the large sea leopard, are most abundant, being found in great numbers on the pack ice. The beautiful white Antarctic seal must surely be a descendant of Rudyard Kipling's great white seal, which roamed the world around to escape cruel and relentless man. Its coat is of a beautiful creamy white, resembling that of the polar bear, but short haired, the color becoming somewhat more intense along the back. Looking at the animal face to face, its coat appears silvery, and the dorsal stripe almost vanishes; but when looked at from behind it assumes a deeper cream color, and the broad stripe along the back becomes quite prominent. The full grown animal may attain a length of about seven feet. The sea leopard is a very striking animal, and, with the exception of the sea elephant, is the largest of all seals. In the recent Antarctic expedition (1892-93) some were met with that measured over thirteen feet in length. Their coat is a dark brown-gray and mottled, becoming paler gray below, and in some cases almost black on the back. A rather striking and not altogether inappropriate name was given to these seals by the sailors in the recent cruise; they called them "serpents," and they do really often look very serpent-like with their long necks and green eyes. Weddell's false sea leopard is more rarely met with, and is nearly as large as the sea leopard, but less shapely and more thickly blubbered; its head is smaller, fore flippers very small, coat more woolly and of a dark brown-gray. Ross' large eyed seal is a beautiful creature, with bright and affectionate eyes; in form and size it is very like the white seal, but its coat is of a beautiful mottled gray, darker toward the back. The sea elephant is the largest of all seals, attaining the enormous length of twenty feet. It is a near relative of the crested seal of the north, and is also found along the Californian coast. The male has a somewhat elongated snout, hence the origin of its name. The females are about one-third less in size. The males are said to come ashore on the Shetlands about the end of August and beginning of September, and in the first part of October are followed by the females. The males are very fat when they first arrive, but get lean toward the end of December, when they leave the islands. Another herd was said to visit the islands about the middle of January—when they renew their hair—and still another in March; by the end of April all returning to the sea. They are very difficult to kill, but, like the other species, allow themselves to be approached even with a club. This seal used to be highly valued for its blubber; in 1821 and 1822 alone as much as nine hundred and forty tons of sea elephant oil was taken from the South Shetlands; and it may here be mentioned that during these same two years at least three hundred and twenty thousand fur seals were also taken from these islands.

THE PATAGONIAN SEA LION.
(*Otaria jubata.*)

It was with the skins and blubber of the first two species of these true seals that the Scottish and Norwegian crafts loaded themselves last season. The slaughter was revolting to one unused to it; within two minutes the seal is brained, deprived of its skin, and its gory corpse left writhing on the snow. Early in the morning, when the sun is beginning to make more or less impression by his rays, and the seals are coming out of the water on to the pack, all hands are ready to take part in the fray. The sails are stowed; the skipper sits in the crow's nest from early in the morning till late in the evening; the two engineers, relieving one another, take charge of the engines; the cook or the steward is on the lookout; some non-combatant takes the helm; all the rest are away after plunder in the boats. Now a full boat is making its way to the ship. She steams toward it. As she nears, the engines are stopped and the boat glides alongside. The cook or the steward rushes from the look-out, the helmsman from the wheel, one working the steam winch and the other unswitching the skins, while the boat's crew swallow a hasty meal. Their boat being unloaded, they are off again for another fill. Another boat is seen approaching, and away the ship goes again, dodging this piece of ice, charging that piece with her sturdy bows, boring away where the ice lies closely packed, rounding this berg, and on to the next, until she reaches the boat, which is down to the gunwale in the water, with its crew cautious, plying their oars as they lie crouched upon their bloody load. So it goes on from day to day; "hay is made while the sun shines," and the pile of skins and blubber rises high upon the ship's deck. Then comes a gale of wind, accompanied by fog, sleet and snow, and the ship "lays to" under lee of a stream of pack ice or a berg. The deck becomes busy with life; the blubber is "made off," and put into the tanks, and the skins are salted. During such inclement weather the seals do not seek the ice, but may be seen swimming about in the water. When the gale is over, at the end of two or three days, the next few days of calm weather are again taken advantage of to continue the slaughter. Thus the periods of gales and calms, which alternate in this part of the world, come in conveniently for sealing; the produce obtained in the calm weather being "made off" during the gales.



SEA LEOPARDS ON PACK ICE.

Concerning the habits and anatomy of these seals much remains to be investigated. During the summer months (December, January, February), as has already been stated above, the first four are to be found on the pack ice, where, during the day, they bask in the sun, digesting the meal of the previous night. Their food consists of fish or shrimp-like crustaceans, and sometimes of penguins. Stones, which were probably first swallowed by the penguins, may also be found in their stomachs. They become so lazy with sleep that a man may dig them in the ribs with the muzzle of his gun, and wondering what it is disturbing their slumbers they raise their head, which quickly falls pierced with a bullet. There may only be one seal on a piece of ice, which is usually the case with the sea leopard seals, but the smaller kinds lie in half dozens and tens, and as many as forty-seven were seen on one piece during the recent cruise. On one occasion several seals were found upon a tilted berg; so high was the lowest edge above the surface of the water that the boat's crew with difficulty clambered up and secured their prey. Yet the seals must have made a leap from the water on to this their last resting place. December seems to be their mating season; about that time they are in very poor condition, and very much scarred. The females appear to be as freely scarred as the males. It was also noted that the seals were most numerous where the water was bluest and clearest—this, in all probability, meaning that they were more numerous on the outside of the pack, since the muddy olive-brown color of the water, due to *corethron diatoms*, seen so frequently in the south polar seas, seems to indicate proximity to the main pack. The males appear to be as numerous as the females, and, in the case of the sea leopard seal and Weddell's seal at least, the males are perhaps rather smaller than the females.

They move swiftly through the water, and can throw themselves eight or nine feet above the surface, covering distances of fully twenty feet. Their moaning in the gloaming of a calm gray day comes as a weird sound through the haze, and makes the icy solitude more lonely, adding awe to a scene already full of fascination! They seem to wonder at man, and not recognizing him as an enemy, they allow him to approach, only to be laid low with club or bullet. It is a matter of great regret that they should be so indiscriminately massacred; there is no regard for sex or age, and even females heavy with young do not escape. If fleets of sealers continue to visit the south, there should be some law of protection, otherwise there is no doubt that, like the southern fur seals at the beginning of the century, these Antarctic seals will be exterminated.—*Knowledge.*

THE PECTEN OR SCALLOP.

By NICOLAS PIKE.

PECTENS are found the world over; and 176 species have been described and figured now existing and many fossil ones. Yet few know more of them than the form of the shell and the luscious morsel it contains. The uses of the pecten are and have long been many and varied.

The "scallop shell" has had world-wide fame since the days of the crusades. The pilgrims to the Holy Land were recognized by one of these shells fastened on the front of the hat and one or more on the cloak, as ensigns they were warriors of Christ, to free the sacred soil from paganism. A shell may still be seen on many a coat of arms dating from that period. How fruitlessly such wealth of life and treasure was spent history's pages tell; but the scallop lives on and flourishes through all the centuries. The shell used was the *P. jacobeus*, abundant on the shores of the Mediterranean.

Not alone was it a Christian emblem, but is said to have been employed as a drinking cup celebrated in Ossian's "hall of shells." This is supposed to have been the *P. maximus*, common on the shores of Great Britain and Ireland. In some countries the poor people use the large shells as plates. In restaurants in Paris delicate preparations of mushrooms are served in them, and in England oysters are scalloped in them. I once saw them in Gallicia, Spain, used for side dishes filled with fish paste and garlic.

The shells of most of the species are beautiful when well prepared; those of the Indian Ocean are said to be the handsomest. Some have become articles of commerce and all kinds of fancy bags, baskets and boxes are ornamented with them. Some of the shells are large, stout and heavy, while others are thin and transparent.

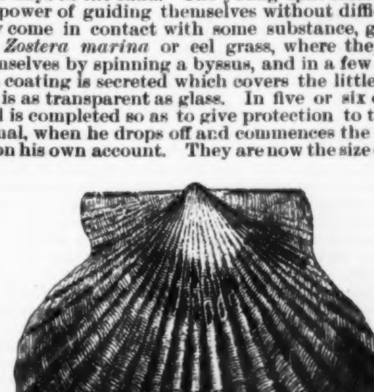
The pecten of our coasts is the *P. irradians*, which grows to a fair size, and is much sought after for its strong muscular abductor muscle, familiarly known as "scallops." Though this muscle is the only part of the animal sold as food here, yet the whole pecten is credited as being good and wholesome, several species being eaten.

The scallop is very abundant on the shores of Long Island, also is found from Cape Cod to Cape May, but little of its life history is known generally.

Unlike the oyster, which is a complete fixture to its bed, the pecten is perfectly free, and shifts about from place to place. It has the power of making frequent and sudden contractions of its muscles, by which means it moves rapidly through the water, making its capture difficult. This movement is made by quickly closing its half open valves and forcibly expelling the water, and is backward, by a sort of reaction. This action, repeated many times, compels the animal to move in spite of itself, enabling it to avoid danger and reach the desired spot. Some naturalists assert that when raised to the surface of the water, the pecten half opens its shell and the upper valve serves the purpose of a sail (?) Aristotle first noticed that it had the power of leaping when out of the water.

Miss Catlow mentions that a basketful of common pectens placed near the water was speedily emptied, by the individuals springing from their confinement to their native element. M. Lesson immersed a basket of pectens in the sea, the water coming to within six inches of its rim. He says, the individuals which formed the superior layer, constrained in their movements by those that were beneath, after many efforts succeeded in leaping from their prison. No sooner did they fall upon the water, than, by striking their valves rapidly together, they ran or rather skipped a few seconds upon the surface, and then sunk to the bottom. In this way all the contents of the basket disappeared in fifteen minutes. The Rev. D. Landsborough observed young pectens when less in size than a sixpence swimming in a pool of sea water left by the ebbing tide. Their motion was rapid and zigzag, and it seemed to him that the sudden opening and closing of the valves gave them the power of darting like an arrow through the water. One jerk carried them some yards and then by another jerk they were off in a moment on another tack.

In my studies of this curious animal I found it very difficult to pursue them on account of their habits. They throw off the spat like the common oyster, only unlike it, the growth is rapid. After the females have done spawning they frequently bury themselves for some days in the sand. The young spat seem to have the power of guiding themselves without difficulty till they come in contact with some substance, generally the *Zostera marina* or eel grass, where they attach themselves by spinning a byssus, and in a few hours a thin coating is secreted which covers the little animal and is as transparent as glass. In five or six days the shell is completed so as to give protection to the little animal, when he drops off and commences the battle of life on his own account. They are now the size of a pea, but their growth is rapid and they become very active, darting about for food. Those I carefully watched in an inclosure in Huntington Bay grew so rapidly that in seven or eight weeks they were as large as a silver dollar and ready for the market.



PECTEN IRRADIANS.

A favorite location of this animal is where the water is shallow, generally near the banks of rivers and bays opening out to the sea, where the bottom is sandy and there is a good growth of eel grass. The food of the scallop is similar to that of the oyster, and minute diatoms are found in the stomachs of the young when ten days old. At the approach of cold weather the scallop goes into deeper water and often buries itself in the sand, as some were brought up in my dredge I had unearthed in the latter part of November.

The scallop breeds from June to the latter part of

August. This mollusk has great tenacity of life, as the following shows. While studying at Huntington one summer, I captured quite a number, as I am very partial to shell fish food. Some of them were cooked and eaten, while nearly half were very carefully laid away in a cool place under the stone steps of my house, and were forgotten. A handful of seaweed had been placed over them, and there they remained for over ten days. When brought out they seemed all right and in good condition, but to make sure I took the basket to the shore to wash them in the salt water. I left them soaking in it for a short time, and when I returned, to my surprise and disgust they had all managed to escape but one or two, and they finally leaped out, skimmed along the surface a few feet, and then dropped quietly out of sight. It requires some skill in the handling of these bivalves, and if you catch them by the naked hand, there is danger of being well paid for your temerity, for they often nip the flesh so as to bring blood and cause sharp pain.

The animal is shaped to the shell, "mantle freely open, with pendent margins, the inner like a curtain finely fringed; at its base a row of conspicuous round ocelli, surrounded by tentacular filaments, gills exceedingly delicate, crescent shaped, quite disconnected posteriorly, having separate excurrent canals; lips foliaceous; palpi truncated, plain outside, striated within; foot, finger-like, grooved, byssiferous in the young."

It is singular that this animal has been so neglected by naturalists, as it has become quite an important article of fish food, and finds a ready sale in our markets. It is wholesome and nutritious as the oyster is and I believe could be as easily propagated as that succulent bivalve. The large bays and rivers of Long Island Sound are admirably suited for this purpose. Thousands upon thousands of bushels could be raised yearly with very little outlay. It is not generally known that the whole animal is edible, but I find it was used for food at a very early period. What quantities of good food are daily thrown away and nothing utilized but the large abductor muscle!

Not alone is there waste in throwing away the pecten, but the small use made of other shell fish. In London over 1,000,000 quarts of mussels, 4,000,000 quarts of periwinkles; and 750,000 quarts of cockles are sold yearly. The two latter are not of much account here, though they could be cultivated. Of mussels we have the finest kinds in abundance, and their fisheries only want development. How many half starving families who cannot afford to buy meat could get good, wholesome and cheap food if the mussel was better known!

[Continued from SUPPLEMENT, No. 942, page 15062.]

ALLOYS.*

By Prof. W. CHANDLER ROBERTS-AUSTEN, C.B., F.R.S.

Lectures I. and II.

THE question now arises, How are these instruments calibrated? To describe the methods at length would demand more than a single lecture, and the reader may well consult the papers to which reference is given.† It should be stated, however, that the calorimetric method of Violle has enabled the melting points of general refractory metals, such as silver, gold, palladium and platinum, to be determined, and these have afforded a secure basis for the work of calibration. The classical work of H. St. Claire-Deville, and Troost with the air thermometer, to which reference has already been made, has rendered splendid service by enabling us to measure accurately high temperatures and to state the results in the degrees of the ordinary thermometric scale.

The most useful data to bear in mind are:

The melting point of zinc	415° C.
" " " " aluminum	625°
" " " " silver	954°
" " " " gold	1,045°
" " " " palladium	1,500°
" " " " platinum	1,775°

By suitably protecting either the thermo-couple or the Callendar resistance coil (Fig. 5), and surrounding them by masses of any of these metals, it is not difficult, provided care be exercised, to determine the points at which they either "freeze" or melt, and thus to calibrate the instruments, but such experiments demand much skill and familiarity, both with working at high temperatures and in manipulating the precious metals.

There are various other pyrometers, but they are better suited for industrial work than for the purposes of research, and will therefore not be described here.

Of all the varied pyrometers, much may be said in favor of the electrical ones, which involve the use of the galvanometer. It will have been evident that, in the case of either of them, the spot of light from the mirror may be received on a sensitized plate, and very slight variations of temperature can then be recorded automatically. As regards the two electrical methods, much advantage may be claimed for the one that depends on the use of a thermo-couple, which is itself very small, and if injured, can be readily replaced. It can, moreover, if suitably protected, be placed in the midst of a few grammes of metal which is being submitted to thermal treatment. The little mass of metal may not be heated beyond redness, or the operation may involve its fusion and volatilization, but a permanent record can be obtained of minute changes in the behavior of the metal, if they are marked by the evolution or absorption of heat such as accompany the passage of a metal or alloy from a normal state to an allotropic one. The various phenomena of fusion and solidification can also be faithfully recorded, whether they occur either in the center of a twenty-ton ingot of steel or in a tiny mass of gold. On the other hand, the little pyrometer may be placed in the blast mains of an iron or steel works, and will furnish the manager with precious information and a trustworthy record of the variations of temperature in the torrents of hot air which pass over the thermo-couple on the way to the seething contents of the furnace.

It remains to be seen what use may be made of this powerful weapon of reasearch in conducting investigations into the nature of alloys.

In employing the thermo-couple for studying the molecular grouping of alloys, it is necessary to bear in mind what would happen if an ordinary mercurial thermometer is plunged into water which is losing its heat to a cold environment. The mercurial column would, as is well known, fall until the water begins to freeze, and then the mercury remains steady until the whole of the water is frozen. The latent heat of the water is gradually liberated during the solidification of the forming ice, and the thermometer ceases to indicate a fall in temperature until the work of solidification is complete. The case is precisely the same when a metal is cooled down to its freezing point. Suppose the thermo-couple is in connection with the autographic recorder (Figs. 6 and 7), and is suitably protected—though this is not absolutely necessary—and is plunged into the midst of a little mass of fluid gold—some 30 grammes will suffice—which is being slowly cooled. The photographic curve registered by the recorder will be that shown in Fig. 8. Assume

FIG. 8.

that the initial temperature of the cooling mass of gold is 2,000°, the temperature will fall, and the curve registered on the sensitized plate by the spot of light will, when the temperature of 1,045° is reached, suddenly become approximately horizontal, as at A, and will remain horizontal until the mass of gold is solid, and then, but not until then, it will resume its downward course to the point at which the little mass reaches the atmospheric temperature. The same effect would be produced if the thermo-couple were placed in any other metal—lead, silver, platinum or palladium—but in the case of silver and lead, the couple must be protected by clay from the direct action of the metal.

Hitherto we have only considered the case of a pure metal, but directly the mass is alloyed with even a minute quantity of another metal quite a different set of molecular conditions is established, respecting which the autographic curves enable most precious information to be gathered. In fact, the purer the metallic mass is, the sharper will be the angle made by the horizontal portion of the curve, *a*, *b*, with the portions above and below it. The presence of an added element, even though its amount be apparently insignificant, is quite sufficient to destroy the sharpness of the freezing point of any metal which has as yet been examined. If the added metal is present in a very small quantity it apparently remains free, and usually lowers the freezing point of the mass, as will be hereinafter explained, but when a certain proportion of the added metal has been reached, it unites with a portion of the mass, and certain alloys, or groups of alloys, are formed which fall out of solution as the mass cools, and the result is to change the nature of the cooling curve, rounding its angles, and, in extreme cases, obliterating the horizontal part altogether.

Such an extreme case is presented when two-tenths per cent. of aluminum is added to gold (Fig. 9). The

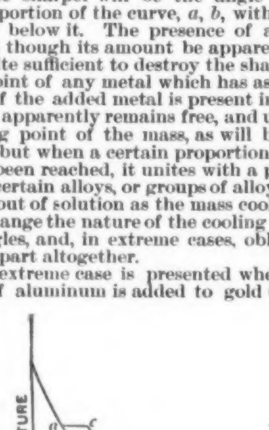


FIG. 9.

horizontal part of the curve is practically obliterated, that is, there is no true freezing point. The normal curve for freezing gold would have followed the line *a*, *c*, but the curve of gold, with two-tenths per cent. of aluminum is that shown at *a*, *f*, with only a faint indication of the freezing of the mass, as a whole, at *f*.

In this experiment the addition of only a small quantity of an added metal has been considered, and that from a somewhat limited point of view. The conditions are widely different when the added metal forms a large proportion of the mass to which it is added. The case of the aluminum gold alloys is very instructive. Suppose the apparatus shown in Figs. 6 and 7 to be so arranged that a series of cooling curves could be taken of alloys, in which the amount of aluminum added is considerable. Starting with pure gold, having a freezing point at 1,045°, successive additions of aluminum lower the point and destroy the yellow color of the gold, until the alloy containing 90 per cent. of gold and 10 per cent. of aluminum is reached. The freezing point of this alloy is 628°, or 417° less than that of pure gold, but then with further additions of aluminum the curve turns, the freezing points begin to rise, and when the amount of aluminum reaches 21·6 per cent., the freezing point is actually a few degrees higher than that of gold itself, and the alloy is a brilliant ruby color. After this point is passed, successive additions of aluminum again lower the freezing points, and they appear to be lowered gradually until the freezing point of pure aluminum is reached.

The case of the aluminum-antimony series, investigated for Dr. Alder Wright by the author, presents a similar case. Dr. Wright observed that the melting point of the alloy, containing 18·7 per cent. of aluminum and 81·3 per cent. of antimony, is considerably higher than that of its least fusible constituent, the aluminum (625°). Accurate measurement by the aid of the curves obtained in the way which has been already indicated showed that the alloy, Al Sb, has a freezing point of 1,050°, or no less than 425° higher than that of aluminum. This aluminum-antimony alloy behaves like many true chemical compounds, stibnite (Sb_2S_3), for instance, the melting point of which is about 530°, though its constituents, sulphur and antimony, melt at 115° and 335° respectively.

In the case of most alloys, as the mass of the melted alloy cools down, groups of alloys, which are atomically definite in composition, appear to fall out of solution, just as in a cooling mass of granite, atomically definite groups of minerals fall out, the mica and the feldspar, tourmaline, or whatever the grouping may be, but the fluid mass which remains need not be, and probably is not, definite in composition. The silver-copper series presents an excellent case in point, and so do the alloys of lead and tin, and it is satisfactory that this autographic method of recording the cooling of a mass of alloyed metal enables the whole history of the case to be accurately traced. Turn, for instance, to the tin-copper series which comprise, industrially, a most important group of alloys. Alfred Riche * determined some of their melting points twenty years ago by the aid of a thermo-couple, which makes the hesitation of experimenters to employ thermo-couples in such investigations the more remarkable, and, I may add, my own tardiness inexcusable. He considered that $SuCu_3$ and $SuCu_4$ alone possess respectively a single definite freezing point. Mr. A. Stansfield, working in the author's laboratory, finds that all the tin-copper alloys appear to have two solidifying points, while some appear to have three.

The bismuth-copper series yield very interesting and unexpected information when examined by this method.† It appears that however small the amount of bismuth alloyed with copper may be, a certain proportion of the bismuth always remains free and does not unite with the copper at all. The cooling curve of any copper-bismuth alloy will, therefore, show at least two freezing points, the lower of which always closely corresponds with the freezing point of bismuth. The general nature of these curves is shown in Fig. 10, in

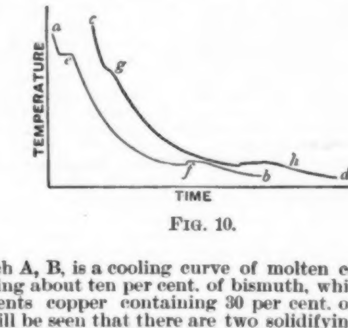


FIG. 10.

which A, B, is a cooling curve of molten copper, containing about ten per cent. of bismuth, while C, D, represents copper containing 30 per cent. of bismuth. It will be seen that there are two solidifying points in each, at E, F, and G, H, respectively, the points, F and H, being at the same temperature (268°), and are due to the solidification of the free bismuth.

One other curious property of metals may be well studied by the aid of this method of obtaining autographic cooling curves. It is well known that certain metals will, if slowly cooled, pass below their freezing point without actually becoming solid, and that when solidification does occur, the liberation of the latent heat of fusion, in some cases, reheats the mass to the melting point, and causes it to glow vividly even though it had previously fallen below redness. Pure gold and silver present such a case. It is more difficult to observe in the case of copper, but, with care, the occurrence of "surfusion," as it is called, may readily be detected in an autographic curve. Fig. 11 presents a

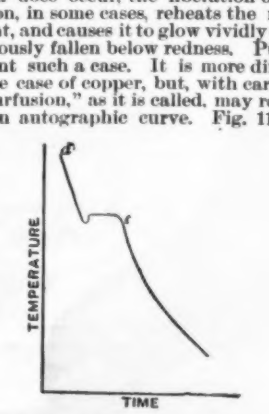


FIG. 11.

case in point. It was obtained from a small mass of very pure melted copper, into which a thermo-couple protected by clay was placed. It will be observed that the curve falls in the ordinary way from A to B, but that at B there is a depression, showing that the temperature fell *below* the actual freezing point, which is marked by the horizontal part of the curve, B C.

The peculiar behavior of certain metals which absorb gases and release them during cooling may also be well studied by the aid of the recording pyrometer.

It is now well known that very complicated changes may occur in the molecules of even solid metals, and the new pyrometric methods enable these changes to be studied with facility. The molecular changes which occur in solid metals are of three kinds:

1st. The grouping of the constituent metals of an alloy may be rearranged.

* Lectures delivered before the Society of Arts, London, 1893. From the Journal of the Society.

† Roberts-Austen, "Proc. Inst. Civil Engineers," vol. cx., 1892. (Violle) "Comptes Rendus," vol. lxxxv., 1877, p. 543; vol. lxxxix., 1879, p. 702; vol. xcii., 1881, p. 866.

* "Ann. de Chim. et de Phys.," vol. xxx. (1873), p. 417.

† "Proc. Inst. Mechanical Engineers," 1893, Part ii., p. 102.

2d. Non-metallic elements present in a metallic mass may change their relation to the metallic atoms; and

3d. The *atoms* in the *molecule* of a solid metal or alloy may be redistributed or rearranged, and this is called *polymerization*.

These molecular changes are almost always accompanied by the evolution or absorption of heat, and can, therefore, be studied by the aid of thermal measurement.

The photographic records have thrown much light on all these cases of molecular change, but for the purpose of minute investigation, another mode of experimenting may be adopted.

Suppose that the spot of light from the galvanometer (Figs. 6 or 7), with which the thermo-couple is connected, does not fall through a slit on to a sensitized plate, but on to a screen placed at some distance from the galvanometer. This screen may be forty feet long, and may be suitably divided into degrees. The room must, of course, be darkened, so that the spot of light may be readily visible. The screen is fixed, and, therefore, the spot of light will traverse it horizontally, and the freezing of a metallic mass would simply be indicated by a more or less prolonged arrest of the spot of light during the solidification of the metal. Suppose, however, that it is not a question of studying the behavior of a freezing metal, but of one which, though it may be strongly heated, is still solid. Take, for instance, the case of a piece of steel of somewhat low carburization which is being slowly cooled. Here the molecular behavior is very complicated. M. Osmond and myself, and, recently, other experimenters, have studied this behavior minutely. There will be at least two arrest points, and probably three, as the pieces of steel cool from bright redness. One of these will occur at a temperature which varies slightly, but is somewhere close to 650° C., and is caused by a change in the relations between the carbon and the iron. An ordinary photographic record obtained on a plate about ten by six inches would simply show a bend in the curve of about the form and amplitude shown in the sketch (Fig. 12). If, however, it is wished to

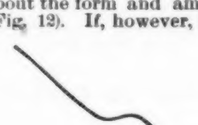


FIG. 12.

study this particular change more fully, the following plan may be adopted: Assume that, in indicating temperatures up to a white heat, the path of the spot of light along the screen is some forty feet, then it is easy so to arrange the experiment that the spot of light may be received (at the critical part of its path which it is desired to study) on a second but smaller screen, say four feet square, which may be moved upward at a slow but uniform rate of, say, an inch a second. The spot of light from the galvanometer may be divided by the images of cross wires, and, as the point of intersection of these wires is clearly visible on the moving screen, its position at any given moment may be recorded, by hand, with a pencil mark. The result is, that the portion of the cooling curve which represents the "recalescence" of iron, instead of being a small sinuous line, shown in Fig. 12, becomes a loop four feet across, of the form shown in Fig. 13. The

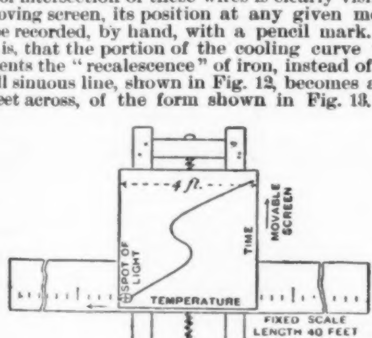


FIG 13.

same degree of magnification may be applied at any period during the cooling of the steel, and it enables the molecular change in the iron which occurs at 855°, that is at a higher temperature than recalescence, to be submitted to a very rigorous investigation. For the purposes of lecture demonstration, it is only necessary to fix a screen of paper on a light frame, and place it like a canvas on an artist's easel, which is provided with a vertical screw for elevating the screen, but it will be evident that for purposes of delicate research some method of uniformly moving the screen could readily be devised.

It is now possible to study the behavior of alloys at high temperatures and to obtain photographic records of the molecular changes by the aid of a simple and trustworthy appliance, which is considered to afford "incontestable" results by so distinguished a pioneer in molecular research as M. Raoult.

THE PURIFICATION OF WATER BY PRECIPITATION AND SEDIMENTATION.

By Dr. PERCY FRANKLAND, F.R.S.

IN an interesting article on "Recent Improvements in the Manufacture of Aerated Waters," published in *Industries and Iron* on the 27th October last, reference is made to some experiments which I made some years ago* on the remarkable bacterial purification which may be procured by agitating a water with certain substances in a fine state of division, and allowing subsidence to take place. In this manner I found for the first time that bacteria are carried down together with the coarser suspended particles in the water. The substances I used were spongy iron, chalk, animal charcoal, vegetable charcoal, coke and other materials, the coke being especially effective, for after agitating the water for fifteen minutes with one-fiftieth of its weight of this material in a finely divided condition and allowing it to subside for forty-eight hours, the supernatant water was on one occasion absolutely sterile or did not contain a single organism.

It may interest your readers to know that I have quite recently been examining the processes and value of sedimentation, as it takes place on the large scale in waterworks reservoirs, used for the storage of more or less turbid water before submitting it to sand filtration. As these are so far the only experiments which have been made on the large or practical scale, they are of especial interest in bearing out the results which I obtained previously on a small scale in the laboratory.

The object of these reservoirs is, as every one knows, to enable some of the coarser particles in suspension to subside before running the water onto the several filter beds, so that the latter may be taxed with the minimum amount of suspended matter. Although such reservoirs have been constructed without any view to the bacterial purification of the water, this actually takes place to a very remarkable extent, as the following investigations carried out at the works of the London Water Companies show very clearly. Thus, in the first instance, the water in a large cemented reservoir belonging to the Grand Junction Company was examined. The water in this reservoir had been obtained from the Thames at Hampton, and the greater part of it had been stored for six months. Now, I have repeatedly shown in the course of the periodical examinations which I made of the London water supply for the Local Government Board, that this raw, untreated water contains sometimes as many as 92,000 bacteria in one c. c. of water, while the smallest number I have ever found is over 1,000. This reservoir water taken from two different ends of the basin contained, however, only 464 and 368 micro-organisms per c. c., showing that a most remarkable bacterial purification had taken place during the storage of this water.

The value of this process of sedimentation was even more strikingly brought out by the following investigations made at the West Middlesex and New River Companies' works respectively. The Thames water is run successively into two reservoirs at the West Middlesex works, where it remains for some time before being run onto the filter beds. The raw river water running into the reservoir on this occasion contained 1,437 bacteria per c. c.; in the water running out of this reservoir only 318 were found, while after passing through the second reservoir only 177 were present. In the case of the New River Company's water I obtained equally striking results, for, while this water (a mixture of river with spring and deep well water) contained 677 as running into the first reservoir, in that flowing out of this reservoir 560 were present, while after remaining in the second reservoir only 183 micro-organisms were found per c. c.

The hygienic importance of these results is obvious, for, should pathogenic bacteria be present at any time in the raw, untreated water, while some diminution in their numbers will take place already in the course of a river's flow, on collecting the water in these reservoirs there is additional opportunity afforded for their removal by the natural processes of sedimentation which I have shown take place to such a remarkable extent.

It is, therefore, of great importance that in the purification of all water for hygienic purposes the maximum amount of sedimentation should be allowed to take place before the processes of sand filtration or other methods of purification are resorted to.—*Industries.*

* "The Removal of Micro-organisms from Water." *Proc. Roy. Soc.*, 1885. *Transactions* Institution Civil Engineers, 1886.

PLANT CHEMISTRY AND BACTERIOLOGY.

By HENRY WURTZ, Ph.D.

AMONG the many wondrous chemical laboratories in which Dame Nature employs herself without ceasing, those which occupy the cells of plants are in a high degree the most mysterious, inscrutable and astonishing in the results they present to us. Although some few animals secrete or excrete materials of peculiar and exceptional characters and qualities, yet the great majority of their products are very closely similar, in the main, in composition and character, when from animals under normal conditions. Their principal plastic constituents also are usually much the same. But in the vegetable kingdom we find that almost every family has its peculiar and characteristic product or products, found often in no other. Moreover, ordinary plants deal with the simplest compounds of the chemical elements of matter, and are constantly occupied in building up from these more elaborate compounds of the greatest variety and complexity, endowed with potential chemical energies great in amount and variety. These the animal, under normal conditions, is continually occupied in consuming and destroying, and reducing back again to the simplest compounds, which the plant immediately proceeds again to build up into complexity, and endow with energy, for the animal again to use up. The plant is always building beauteous structures, temples and palaces of molecules, merely that the animal may destroy and tumble them into ruins again. The plant process is one of deoxidation or decombustion, while the animal process is always one of oxidation or combustion. The plant, however, does not accomplish this decombustion and accumulation of potential energy in the products thereof, by virtue of any inherent power of its own. Plant life, in some wondrous way, directs, controls, and condenses the energies brought by the heat rays and chemical rays from the sun. With some strange exceptions, of which further on, the plant races are children of the sun.

The present writer wrote as follows on this subject in 1877: "Within the leaf of the plant resides the inscrutable vital influence which is able, with the assistance of the heat of the solar ray, to set up the most mysterious of chemical laboratories, wherein such substances as cellulose and starch (and through these sugars), with still more complex proteid bodies, are elaborated from the simple compounds, carbonic acid and water. **Generations may pass away at the present** rate of progress of chemical investigation before any real insight will be gained into the chemistry of the plant leaf."*

Nevertheless, the writer was not optimistic enough here. But a few years subsequent to this date, an important insight was actually gained into the way in which these plastic constituents of plants are chemically built up in the leaf cells. A German chemist, Baeyer, discovered that the process consists of two successive steps: *First*, and essentially, in the formation in the leaf, from the moisture and carbon dioxide of the air, of the compound *oxymethylene*, CH_2O, also called *formic aldehyde*. This is accomplished by the operation above referred to, simply by the deoxidation (or dissociation by the energy of the solar rays of the carbon and oxygen) of the carbon dioxide, commonly, but inaccurately, called "carbonic acid," of the atmosphere, under the influence of this mysterious vital influence of the plant.

The latter is thus able to transfer the energy of the sun rays to the carbon of the oxymethylene—which comes from the decomposed carbon dioxide—in the form of chemical potential energy, which would be given out again if the oxymethylene were set on fire and burned. The chemical equation of this primary transformation is thus:

$$H_2O + CO_2 = CH_2O + O_2;$$

free oxygen passing into the atmosphere, as we know is constantly the case, from the growing leaf. It will be seen that the other product besides the free oxygen, that is, oxymethylene, may be looked upon as virtually a compound of carbon and water, H_2O. As it is a gaseous body, which is largely soluble in water, such a solution may be looked upon as in effect a solution of carbon in water. This body, oxymethylene, considered to be formic aldehyde, thus continually being formed in the plant leaf by a natural process, may be produced artificially by passing a mixture of vapor of wood alcohol and air over a red hot helix of copper or platinum wire contained in a glass tube. Such helix may be heated by an electric current.

Second.—Like other aldehydes (with many other organic bodies) this formic aldehyde has a fashion of forming *polymeres*, so called. In this case, just as with common or acetic aldehyde, three molecules combine together into one, thus:

$$3(CH_2O) = C_3H_6O_3.$$

This triplicated molecule constituting now a *solid* body instead of a gas. Such solidification of the gaseous compound takes place spontaneously in a concentrated watery solution. Now it happens (or rather results, for nothing can be rightly said to *happen* in chemical transformations, all being subject to fixed laws) that by carrying this polymerization twice as far as above, which the leaf knows how to do, though we cannot yet do it, there results $C_6H_{12}O_6$, which is *glucose*, or fruit sugar. Then by separating from this a molecule of water, H_2O, we get $C_6H_{10}O_5$, which is *starch*. By a second doubling up of glucose, and taking out a molecule of water, we get $C_{12}H_{22}O_{11}$, which is *cane sugar*. By taking out another molecule of water, we get $C_{12}H_{20}O_{10}$, which is *cellulose*, the main component of wood and of all plants. It may be observed that in all these cases the resulting polymere may still be regarded as a compound of carbon and water, and the energy that has come from the sun is locked up solely in the carbon atoms, which all come from the carbon dioxide gas of the air. There is no more beautiful development of chemical science than the one we have here been following up.

It is desirable here to emphasize the fact that these are developments mainly of *chemical* science. The botanists, biologists, and microscopists have, until of late, had the great fields of investigation of plant structure, with the transformations and metamorphoses that proceed in plant cells, almost wholly to themselves. The time has fully come, however, when chemistry must step in, and do what man has been endowed with the power to do, namely, to subdue this kingdom of nature. The laboratory and the microscope have indeed already begun to co-operate in earnest, and will jointly achieve discoveries which neither alone could hope to approach. At last summer's meeting of the British Association for the Advancement of Science, several papers were read by chemists of distinction relative to this subject. So many facts of interest and importance demonstrative of the necessity of applying chemical knowledge and laboratory methods to the study of microscopic and microbic vegetation, and their relations to health and disease, to life and death, that a strong impression was produced. The project was started and urged of the immediate "establishment of an institute for research where chemists, biologists and pathologists could mutually assist one another."

The work of the microscope, which has laid the foundation for the great structure of plant chemistry that is now soon to arise, has not been confined merely to the morphology, or study of the forms and minute structure, of such plants as we see around us, without microscopic aid—or rather only with that conferred on us by the Creator—the microscope and telescope combined, which gives us our limited *natural* insight into his illimitable creation. The microscope has further developed to us the existence of generations of plants, whose number baffles human speech to convey and the human mind to conceive, and whose importance to the present welfare and future destiny of the human race is greater than that of any other agency in the scheme of nature. These are the so-called bacteria.

At this last meeting referred to of the British Association, the eminent chemist, Frankland, stated that microscopic manipulations and methods had largely failed in the fundamental matter of recognition and identification, with the needed certainty, of some of the more important forms of bacterian life. This, even when aided by the chemical method, now in universal use, of staining the internal structure of these organisms by soaking them with brilliant dyes. Even in the case of the cholera bacillus or spirillum he said that as much difference had been found "between different specimens as between this spirillum and totally different species."

* "Johnson's Universal Cyclopedia," vol. 4, p. 1117. Under "Chemistry of the Vegetative Process."

He added that "morphological tests have consequently been obliged to give way to chemical and physiological tests." The chemical tests are just now undergoing investigation, some being not yet sufficiently familiar to be fully relied on. We may be sure, however, that an immense number of new tests of this class will be discovered when these subjects of investigation obtain a fair lodgment in the laboratory of the skilled chemist.

Frankland mentioned some examples already known. The cholera bacillus gives a characteristic reaction with the compound called *indol*, with which the typhoid bacillus gives none. The latter, however, coagulates milk, but will not cause the fermentation of glucose. Frankland makes the important though obvious statement that an essential to success in the chemical tests between these pathogenic fungoids is *pure culture*, that is, the culture of each germ by itself, without admixture with the others. The special ptomaines, ferments, or banes to animal vitality, which some of them engender, will doubtless each be found to have its characteristic chemical reactions, when obtained free from others. Experiment has shown also that the culture of the same bacterium, when alone, *in differing media*, will in many cases give identical products. There are classes which contain species *identical* under the microscope, and which can only be distinguished now by determining which of them is the morbific one, through actual experiments on animals. Further knowledge will give us chemical means of detecting which of these produces the deadly ferment. One of this kind is the *anthrax* bacillus, the cause of terrible diseases. Frankland also lays stress upon what he calls "educational culture"—modifications of the nature of the baneful fungoids, by culture in special media, so that they no longer produce the poison, just as we know that other plants may be essentially modified, in color, odor, taste, magnitude, and even in animal digestibility, by special cultivation. One point is especially important, if confirmed further; namely, that while the poisonous bacilli may be made harmless by cultural variations, none of the harmless ones have been yet found to become poisonous. Frankland discussed also the effects of sunlight, peroxide of hydrogen and other bactericidal agents; and the necessity that bacteriologists should acquire a profound knowledge of chemistry and of laboratory methods, while the chemist should, *vice versa*, become also a botanist and a biologist.

At this same meeting a most important paper was read by another distinguished British chemist, Warington, mainly on an important branch of the same subject, possessing special interest, and to which a number of chemists have already given extensive research. This is now beginning to bear fruit. It relates to the property known to be possessed by the most abundant bacteria, of producing directly from decaying nitrogenous materials the dioxide and trioxide of nitrogen, the essential components of the nitrites and nitrates.

All the *ptomaines*, or corpse alkaloids, so far as known, all the *tox-albumens*, as a matter of course, and furthermore, in all probability, the serpent poisons, and blood poisons generally, are nitrogen compounds.

Bacteria, therefore, those at least of the non-morbific kinds (which of course make up the great mass of them, most of the morbific or pathogenic species being comparatively rare) are actual scavengers, and do good work in destroying the corpses of animals, which would otherwise, in time, have encumbered the earth. It is because the germs of these organisms are diffused in almost infinite numbers throughout all soils that corpses buried in the earth so rapidly decay and become inoffensive.

It has recently been discovered also, that although sea water is almost destitute of bacterian germs, yet the *floor* of the ocean is loaded with them. Russel found in mud from the Mediterranean, at 164 feet depth, 245,000 microbes in a cubic centimeter, and in mud from Buzzard's Bay, Mass., 30,000 per cubic centimeter.* Also large numbers in mud from the Gulf Stream, 100 miles from shore and 600 feet depth.

Warington states that to bring the nitrogen of dead animal matter fully up to the point of complete oxidation to nitrogen trioxide, requires the successive agencies of more than one distinct tribe of bacteria. The process of nitrification, so far as yet known, begins with ammonia, though it seems probable that even this will yet be found to be itself a product of a special bacterium. One class of microbes has the property of oxidizing the nitrogen of such ammonia to nitrites, or dioxide compounds, but cannot carry it any further. Another class now takes the task in hand and converts the nitrites into nitrates. Neither of these can perform the function of the other.

The nitrate-making bacterium can make nitrates only from nitrites and not from ammonia directly, and the nitrite-making organism cannot make nitrates, either from nitrites or from ammonia. As the germs of both of these tribes usually occur together in soils and waters, nitrites seldom appear, nitrates being usually found.

Warington announces, moreover, on the authority of another bacteriologist, Winogradsky, a most extraordinary new fact, if fact it be. Namely, that the latter has found a bacterium which engenders nitrates *from the nitrogen of the air*. This, he says, will grow and accumulate nitrogen in a solution of pure sugar, with phosphates and sulphates of lime and magnesia, without any nitrogenous pabulum. The sugar is converted into butyric acid. This would confirm the assertions of Ville and others, who have claimed that plants get nitrogen from the atmosphere in some way.

* Equal to about half a million per cubic inch.

ARTIFICIAL INDIGO.

TAKING a retrospect of the general position of the industry which uses as its primary materials benzol and other aromatic hydrocarbons, and builds up from these more complex compounds which find their principal use either in the form of intermediary products or as coloring matters or medicinal preparations, we may consider the results as, on the whole, satisfactory. Manufacturers of coal tar derivatives have been fully employed. The demand has been constantly increasing, and the introduction of new products and the cheapening of the methods used in the production of already established articles have fully compensated for lower prices, and it is certainly most satisfactory to note that this country has participated, if only yet to a modest extent, in the development of this important industry. A large number of patents has again been applied for during the past twelve months, of which the greater part deals with improvements on old or substitutes for existing colors, but there is nothing of an exceptional character to report. I cannot, however, pass from this subject without calling attention to the continued efforts which have been and are being made by chemists to further improve the methods for the production of artificial indigo, which so far possessed only a scientific value, for the reason that this country has a twofold interest in this question. In the first place, we are the principal producers of natural indigo, the annual outturn of which represents a value of about four millions sterling; and, secondly, we are one of the largest, if not the largest, consumers of this coloring matter.

It is now several years since Prof. Bayer made the startling discovery of the synthetical production of one of the most important coloring matters hitherto solely supplied by the agency of nature. The first patent taken out in the name of the professor for the production of artificial indigo was in 1880, then followed a number of patents in rapid succession from 1880 to 1884, having as their primary material either orthocinnamic acid or its homologues or products of substitution. Considerable sums were spent during these years with the object of perfecting the technical methods, and reducing the cost of the necessary intermediate products, but all these efforts were in vain, and artificial indigo remained so far more a chemical curiosity than anything else, except perhaps the very limited use of the orthonitrophenylpropiolic acid.

Little was heard of it by the outside world for some time until attention was again directed to it by Prof. Heuman's beautiful discovery in 1890, which I had an opportunity of illustrating by experiment shortly after, on the occasion of addressing the chemical students at the opening of the session of the Manchester Technical School. Heuman's discovery in the production of artificial indigo proceeded on different lines from those first followed by Bayer, and afterward by others. Heuman heats phenylglycocine with caustic alkalies at about 260° C., when indigo white is the result, which may then readily be oxidized to indigo blue. Here again, unfortunately, notwithstanding the great simplicity of the process, the large destruction of the principal raw material made this process also too expensive for trade purposes.

With all these negative results, so far as the profitableness of the various processes is concerned, chemists have persevered in their efforts to solve the great problem which offers so great a prize, and I will now illustrate a process which might almost be called an extension of Heuman's discovery. In December, 1890, the Farbenfabriken, of Elberfeld, discovered that when phenylglycocine is treated with anhydrous sulphuric acid, an oxidation accompanied by an evolution of sulphurous acid takes place, converting almost instantaneously phenylglycocine into indigo sulpho-acid or indigo carmine. I have here some phenylglycocine (produced by the action of mono-chloracetic acid on aniline) which has been ground up with twenty times its weight of sand in order to moderate the reaction. I now put some of this into a large excess of 70 per cent. anhydrous sulphuric acid. You will notice a yellow coloration, which already indicates the formation of artificial indigo, but in order to make the real color appear it will be necessary to remove the anhydrous acid (SO_3) by absorbing it in a large quantity of ordinary sulphuric acid, when you will notice an intense blue coloring matter. I am now pouring this blue acid solution on a block of ice, when the characteristic color of indigo carmine will be more easily perceptible to the eye and we will dye some woolen cloth with this solution after first neutralizing the excess of acid contained therein.

In the year 1882 the Badische Anilin und Soda Fabrik patented a process for manufacturing artificial indigo by treating the solution of orthonitrobenzaldehyde in acetone with alkali. Bayer and Drewsen in the same year further investigated this reaction, and they found that when nitrobenzaldehyde in presence of acetone is treated with very diluted alkali that first a product of condensation is formed, viz., the orthonitrophenyllactoketone, which on further treatment with alkali is instantly converted into indigo. I have here some orthonitrobenzaldehyde, and am now dissolving it in acetone. We will add to it some water, and put to it a few drops of a caustic soda solution; the ketone is first formed, which you will see will be almost immediately converted into artificial indigo on adding a little more of the alkali solution. This reaction, simple as it appears in its execution, was also doomed to failure, on account of its costliness, notwithstanding Eugene Fischer's process, patented in 1888, for a cheaper method of producing orthonitrobenzaldehyde from orthonitrobenzylchloride.

It was, moreover, impracticable to apply the ketone direct to yarn or cloth and then develop the indigo blue direct on the fiber, on account of its comparatively small solubility in water. Some of these difficulties in the way of the practical application of Bayer and Drewsen's discovery have now been overcome by Kalle & Co., of Biebrich, and though their process may not so far be cheap enough to produce indigo direct, the development of indigo in the fiber appears to me likely to find some application in the arts, on account of the superiority of the shades produced, and the greater resistance to light of the lighter shades, and for the reason that new effects can be obtained by it in printing which would be difficult to produce by following the old process, always provided that means be found to reduce the strength of the caustic soda solution which the patentees specify as being necessary for developing the indigo, as a solution of 21° Be., as recommended by the patentees, mercerizes the cotton.

A few months ago Messrs. Kalle & Co. found that when Bayer and Drewsen's ketone is treated with bisulphite of soda, the bisulphite compound of the ketone is formed, viz., the orthonitrophenyllactoketone bisulphite, and this compound has the great advantage over Bayer and Drewsen's of being easily soluble in water, and hence can readily be applied to the fiber; moreover, to obtain the ketone in a pure state by Bayer and Drewsen's method is more costly. I have here the bisulphite ketone; we will dissolve some of it in water, when you will at once observe its conversion into indigo on the addition of a diluted caustic solution. I will now illustrate the application of this compound to the production of indigo shades on the fiber. This hank of cotton yarn we will pass several times through a solution of the ketone; squeeze it and then take it through a caustic soda solution, when it will be dyed a deep indigo blue. I have also here some cloth that has been prepared by printing upon it a solution of the ketone thickened with dextrin. We will now pass it through caustic soda, when the cloth which was previously practically colorless will be colored indigo blue in all parts which had been impregnated with the ketone.—*Ivan Levinstein, in Journal Society Chemical Industry.*

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